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[Continued from SUPPLEMENT No. 1357, page 21745.]

THE BUILDING OF A MODERN LOCOMOTIVE.*

WHEELS, FRAMES AND OTHER PARTS.

IT is customary at the Baldwin works to use cast steel for driving-wheel centers on fast passenger engines. On freight engines either cast steel or cast iron wheel centers are employed, as may be required, and the new Baltimore and Ohio Consolidation locomotives have cast iron centers, with the exception of the main drivers, the centers of which are of cast steel.

No steel castings are made at Baldwin's, being purchased from other firms; but all cast iron wheel centers are made in the foundry, previously described in the paper on cylinders. A softer grade of iron than that employed in making cylinders is used. The space for the counterbalance weight is cast hollow, as is also the rim; which is split in four sections by narrow gaps, to avoid undue strains while cooling. The wheels, like the cylinders, are thoroughly clean before they leave the foundry; and are then sent to the wheel shop.

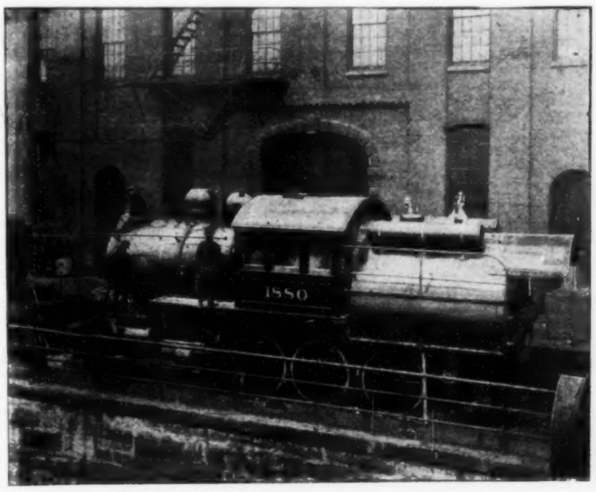
The first operation is to prepare the wheels for forcing them on the axles. They are laid down on special machines with rotating tables, and the hubs are faced and then bored out to size with great accuracy. A keyway is slotted in each hub.

The axles, made of hammered steel, are in the meantime being turned and finished in lathes, all measurements being made to gages to insure uniformity and accuracy. A keyway to match that in the wheel centers is cut at each end of the axle, these keyways being exactly at right angles to each other. The bore of the hub has a diameter less than that of the axle by an amount equal to three-thousandths of an inch per inch of axle diameter. For a 9-inch axle, for example, the hub will be bored to a diameter of eight and nine hundred and seventy-three thousandths inches. The axle is now hung between the uprights of a hydraulic press and one of the wheels set up in front of it, the two being so related that the keyways exactly match. The end of the axle and the interior of the hub are coated with black lead and oil, which acts somewhat as a lubricant when the wheel is forced on. The space between the other end of the axle and the ram of the machine is filled up with metal blocks, and pressure is then applied to the ram and the axle is slowly forced into the hub under a maximum pressure (in a cast iron wheel) of ten tons per inch of diameter. In forcing on a steel wheel a considerably larger pressure can be used without danger of injuring the center. After one wheel is on the axle is turned around and the other forced on in the same way. Keys are then driven into the keyways at each end, and cut off flush with the face of the hub.

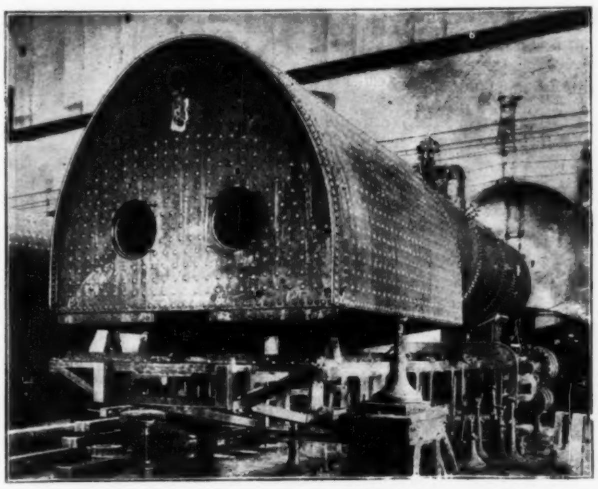
The wheels are now ready for turning, but before they are put in the lathe the gaps in the rims, which have been previously machined, are filled by driving in wrought iron filling pieces. The pair is now set up in one of the large lathes of the wheel shop, a detailed view being given in the cut. These machines can be adjusted to fit wheels for different gages, and are driven by separate electric motors. The faceplates in the largest are 100 inches in diameter, and the wheels are rotated with the machine by means of heavy "dogs," which are clamped to the faceplates. The centers are carefully turned up to the proper diameter to receive the tires, all the measurements being made to gages.

The wheels are now taken out of the lathe, and the counterweights filled by pouring molten lead into the openings seen in the left-hand wheel in cut, until the exact amount required is obtained. Lead is also poured over the wedges previously driven into the gaps in the rim, thus giving a smooth finish at those points. The centers are now ready to receive the tires, which are made of a special grade of steel having great tensile strength. The tires, as they come to the works, are turned both inside and outside. An allowance of one-hundredth of an inch per foot of center diameter is made when

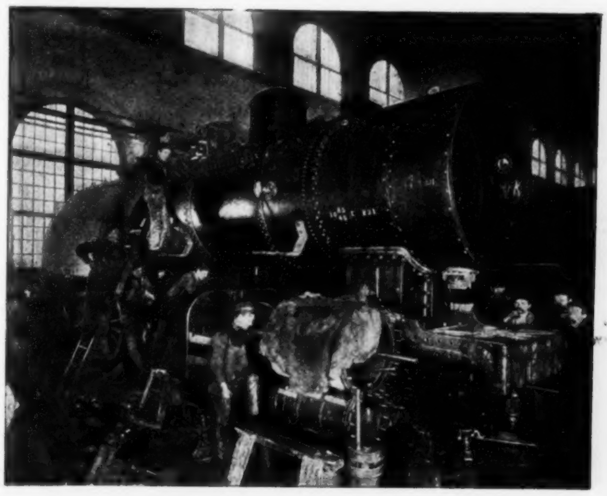
* Reprinted from the Brotherhood of Locomotive Firemen's Magazine.



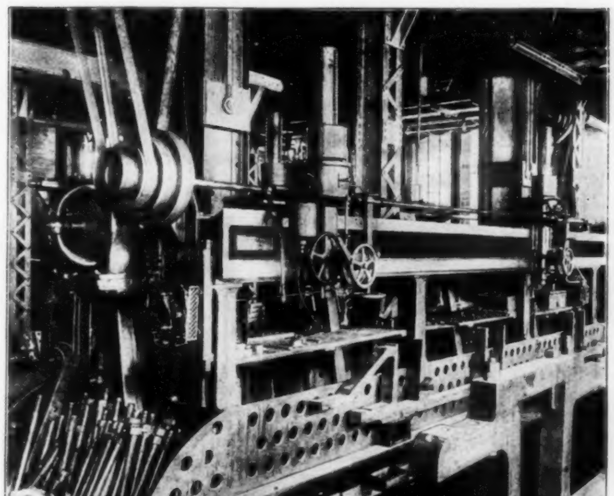
THE ENGINE READY FOR SHIPMENT.



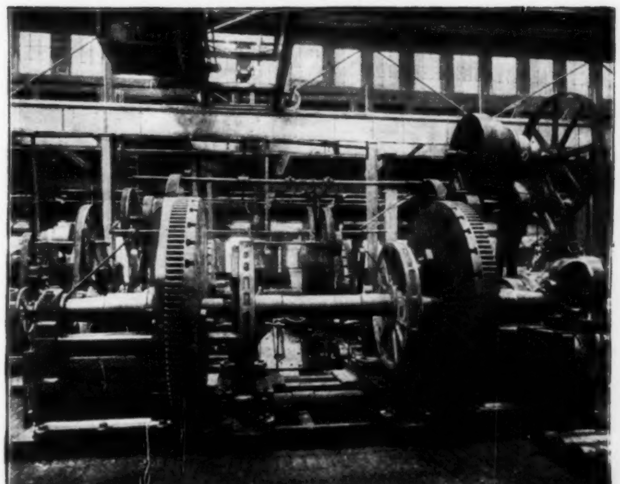
MODIFIED WOOTTEN TYPE BOILER—REAR VIEW.



DRIVING WHEELS IN PLACE.



FRAME DRILL.



WHEEL AND TIRE-TURNING LATHE.

THE BUILDING OF A MODERN LOCOMOTIVE.

boring out the inside of the tires. Thus, in the engine we are considering, the center is forty-eight inches in diameter, and the inside diameter of the tire is turned to forty-seven and ninety-six hundredths inches. The tires are heated in a furnace until they expand sufficiently to slip them easily over the center, a comparatively low heat being enough to increase their diameter by a full eighth of an inch. A stream of water is then turned on them, and as they cool they shrink, and so bind themselves on the center without the n cessity of using clamps of any kind. It is not customary, in domestic practice, to again turn the tires after shrinking them on, although foreign specifications are sometimes more particular in this respect. The tire having been turned up before it is put on the center, the wheel runs sufficiently true after that operation is finished.

The final operation before the wheel leaves the wheel shop is to insert the crank pins. These, like the axles, are of hammered steel, turned up in lathes, to fit the holes bored for them in the crank bosses. They are forced into their seats under hydraulic pressure in the same way that the wheels are forced on the axles. It is unnecessary to use any special devices to prevent their working loose after they are forced into place.

The connecting rods of the new Baltimore and Ohio engines are of "I" section, fitted with the usual strap for holding the brasses, while the coupling rods are of rectangular section, with solid ends and plain bushings. The rods are of hammered steel, all the finishing being done at the works. The machine work is done almost entirely on planers and milling machines, the latter being most extensively used. In working on the body of the rod a milling machine cuts a depression at each end, and the body is then finished to size on a large planer. These machines carry two tools and work on a pair of rods at the same time. In the case of an "I" section rod of uniform size throughout a milling machine can be used to cut out the channels; but on a connecting rod which is made tapered this cannot be done, and the milling machine is only used to cut a depression at each end, the rest of the channel being cut out by the planer. The bodies having been machined to size, the coupling rods are put on drill presses and the holes for receiving the brass bushings carefully drilled out by means of special tools. The circular ends of the rods, and all large fillets, are finished on milling machines. In finishing an end the rod is laid down on the rotating table of the machine and so placed that the center of the crank pin hole coincides with the center of the table, and the tool thus cuts to an exact circle. The oil cups are forged solid with the rod, and are carefully machined and drilled with a special tool.

The bushings for the rods, after having been finished, are forced into place on a hydraulic press, which prevents their working loose and keeps them from turning. The straps and keys for the connecting rods are carefully machined and finished by scraping to assure an exact fit, and more or less hand-finishing work is done on the rods themselves, the end faces being carefully scraped.

Both wrought iron and cast steel frames have been used in the new Baltimore and Ohio engines. The castings are purchased; but the wrought iron frames are forged up at the works from the raw materials. This process is a most interesting one, and we may well devote some space to describing it.

The frames are forged up from small pieces of selected wrought iron scrap, which are first welded into thin slabs. A number of these slabs, piled together, are then welded and gradually worked into a frame; the top rail of which, in a large engine, is usually formed in two sections, which are welded together after the pedestals are forged on them.

The pieces are heated in a furnace conveniently placed with reference to the hammer. The fuel is in a separate chamber, and the hot gases, on their way to the chimney, pass through the flues of a boiler, thus raising steam with which to work the hammer. The piece being forged is slung from a crane, and handled by means of a large pair of tongs. The furnace is of sufficient size to contain two frames at the same time; and while one is being worked under the hammer the other is being heated.

The top rail of the main frame is always forged, if possible, in one piece; but in the case of a large Consolidation engine the frame is too long to be conveniently handled, and hence is forged in two pieces, which are afterward welded together. It is the most recent practice at these works to forge the section for all four sets of pedestals in one piece and then weld on the tail. In the case of the Baltimore and Ohio engines, however, the section for the second, third and fourth pairs of pedestals was forged solid with the tail piece; and the section for the first pair of pedestals was then welded to it. This is called the "main weld," and it is not made until after the pedestals themselves are forged on and the middle and back braces welded in.

As the two sections for the top rail are forged into shape the lugs for the pedestals are formed on them by means of suitable tools. A special gage, on the end of a long rod, is used for making measurements of breadth and depth, the length being also worked to a gage. The breadth and position of the lugs are determined by means of a sheet iron templet. Another hammer, in the meantime, is forging the pedestals, which are provided with lugs projecting from them at right angles. These lugs have their ends notched like a V, and to them the middle braces of the frame are welded, as will be explained shortly.

The sections of the top rail and the pedestals having been finished, the latter are welded to the former. The lug on the rail and the top of the pedestal are first "scarfed" so that they fit properly. The under side of the lug is rounded to a convex surface, and a corresponding depression is formed on the upper end of the pedestal. The two are then brought to a welding heat and pounded together under a small steam hammer.

The pedestals having all been forged on, the middle braces are cut to the proper length and their ends pointed to fit into the notches cut in the lugs on the pedestals. The fit is an exact one, holding the braces, while cold, firmly in place. The joints are then brought to a welding heat, and the union completed by blows from sledge hammers.

The back brace is secured to the tail piece by an ordinary lap weld, its other end being "scarf welded" to the rear pedestal like the middle braces.

The pedestals and braces being forged on, the next operation is to effect the main weld. The long section of the frame is notched and the short section finished with a corresponding point, and the pieces are then laid together and heated in an open forge. When a high heat has been attained the end of the frame is struck with a heavy iron ram, which effects a partial union and holds the sections together when they are removed from the fire. The main weld is completed on an anvil by means of sledge hammers.

The frame is now a complete forging in the rough, and during the remainder of the process cast steel and wrought iron frames are treated practically alike. The sides are finished on enormous planers, which are large enough to work on a pair of frames at the same time, and take a continuous cut from one end of the top rail to the other. The pedestals are finished individually by taking short cuts across them, as time is saved in this way. All the inside work, such as finishing the lower surface of the top rail and the front and back faces of the pedestals, is done on slotting machines, the largest of which can work on three sets of frames at once. There are practically two machines on one bed, each being driven by an electric motor and independent of the other. This arrangement greatly facilitates rapid working.

The surfaces having been planed and slotted, the frames are sent to the shop and here drilled on special machines, one of which is seen in our engraving. This work is all done to gages, thus rendering like frames absolutely interchangeable. The front rails are clamped to the main frames and the two drilled together to insure an accurate fit.

The drilling having been finished, the frames are practically complete, and ready to go to the erecting shop.

Many interesting processes are employed in manufacturing the various smaller parts which enter into the construction of the modern locomotive, but in this connection only a brief reference to some of them can be made. The various parts of the link motion are of hammered iron, case hardened for wear wherever there are sliding surfaces. The pistons are light castings, each being fitted with two cast-iron snap rings to prevent leakage. The rods are of iron, accurately finished and ground. The crosshead is a steel casting, carefully machined, the wearing surfaces being covered with a layer of babbitt. Tapered holes are provided for the piston rods, which fit into them accurately, and are held in place by a shoulder which is turned on them, a large nut being screwed on the outer end of the rod. The eccentrics are of cast iron, as are also the journal boxes. These are finished on large planers, a whole row of them being set up and worked together, thus assuring uniformity and rapid working. The springs are of cast steel, the material being subjected to special inspection, as its composition must conform to strict requirements. The leaves forming the springs are cut to the proper lengths, and then assembled and held together in a clamp. The band surrounding the center is of wrought iron, which is welded to form a rectangle, and then heated. It is put over the spring while hot, and pressed into shape on a hydraulic machine. The shrinkage of the band, in cooling, holds the leaves firmly in place. The hangers and equalizers for the spring rigging are of wrought iron, forged into shape under drop hammers. An interesting detail is the forming of the steam dome covers used on these engines. The tops are hemispherical, and are formed of Swedish iron. This material is very ductile, and a flat sheet of it is worked over a suitable form by means of hammers, until it becomes a perfect hemisphere, with a smooth external surface. The dome casing is formed of three pieces, which are brazed together, and give a smooth outside finish. The various brass fittings are machined from castings made in the brass foundry. The metal is brought to the melting point in crucibles, which are placed in the furnace; for, unlike iron, the brass and the fuel cannot be mixed together in the same chamber.

A most important feature of the modern locomotive is the tender, the design and construction of which has recently been receiving a great deal of attention. The tender shop at the Baldwin Locomotive works is an extensive plant within itself, and some account of the construction of tenders will not be out of place here.

The Baltimore and Ohio Consolidation engines are equipped with tenders having 5,000 gallon tanks and wooden frames mounted on two four-wheeled diamond-framed trucks. The frames are built of oak and have heavy end sills, measuring ten by twelve inches, and four longitudinal timbers measuring six by twelve inches. Additional wooden braces run across the frame at its center, and at two intermediate points there are cross braces in the shape of heavy trusses, built up of bar iron, which carry the center bearings for the trucks. The timbers are held together by means of bolts and tie rods. The frame is covered with heavy planking, and the floor of the coal space is further covered with steel plates.

The tank is of the ordinary "U" shape, the walls of the coal space being vertical all around. Steel plate is used in its construction, the top and bottom each being made of three sheets, while six sheets are used to form the side walls. The rivet holes around the edges of the sheets are punched on most ingenious machines, which automatically feed the plate, punch it, and at the same time shear the edge. The top and bottom of the tank are riveted to the side walls by means of angle bars, which are punched to the same pitch as the plates, on an automatic machine, thus assuring the fact that the holes will match. The angle bars are riveted to the top and bottom sheets by a hydraulic riveter. This is accomplished while the rivets are cold, the machine forming a flat head, and enabling the work to be done very rapidly. In the meantime the sheets for the side walls have, where necessary, been bent by means of machine-driven rolls, and they are now assembled with the top and bottom sections, and the whole united by a few bolts. As it is impossible to use the machine riveter after the tank is assembled, the remainder of the work is done by hand. The heads are round, and are formed on the outside of the tank in a suitable die. Half-way up the side suitable braces are provided all the way around, to keep the walls from bulging out owing to the pressure of water. The riveting having been finished, the seams are calked with a round-nosed pneumatic tool, to render them water-tight. The tank is then filled, and again calked wherever leaks develop.

This work being completed, the tank is mounted on its frame, to which it is secured by angle irons; and it is then appropriately painted. There is one interesting feature in this connection. The capacity of the tank is plainly shown on the back, and on the front end of one of the water legs; while on the other leg is a scale showing the amount of coal in the tender. The scale runs up to 7,000 pounds, that being the capacity when the coal space is filled to the top of the tank, but not heaped.

The trucks, in the meantime, have been finished, and are now rolled into place. They have cast-iron M. C. B. journal boxes and double elliptical springs, and are braced with box girders built up of plates and angle bars, which carry the center castings; the truck bearings in the frame being set in heavy trusses, previously mentioned. After assembling the air-brake rigging and a few other details, and varnishing the tank, the tender is ready to leave the shop. It weighs about 100,000 pounds when loaded and ready for the road.

ERECTION OF THE LOCOMOTIVE.

The erecting shop at the Baldwin Locomotive Works measures 160 feet wide and 337 feet long. It is divided by the row of columns into two bays, each of which is spanned by two Sellers electric traveling cranes of 50 and 100 tons capacity respectively. With the shop as at present arranged, there is space available for erecting about seventy engines at one time.

The accompanying illustrations are presented to show the progress during the erection of one of the Baltimore and Ohio Consolidation engines. The pictures do not all represent the same engine, but the locomotives are alike in all particulars, and the different stages are clearly shown.

The first thing is to set up the cylinders, which are placed on screw jacks at about the height above the ground that they will occupy in the finished engine. The upper surface of the saddle, to which the smokebox will be bolted, is chipped off by hand to insure a good fit. A line is scribed around the edge of the flange, and the casting chipped down to it over the surface surrounding the bolt holes, the seats for the steam and exhaust passages having been finished before the casting reached the erecting shop.

As a rule, the engine frames are set up before the boiler is put in place; but in the case now under consideration, the boiler was ready first, and was set up without waiting for the frames. After the smokebox shell has been drilled to match the bolt holes in the upper flange of the saddle, the boiler is bolted to the latter, the cylinders being still supported by jacks. The firebox is supported, on each side, by a jack set on a proper support. Some of the cab fittings are already in place, the cab being set, in this case, over the middle of the boiler.

As soon as the boiler is in place, the tubes are inserted. They are of iron, and have a copper ferrule at the firebox end, to insure a water-tight joint. The holes in the tube sheets are reamed out sufficiently large to enable the tubes to slip readily into place. By means of a special tool, operated by hand, the tubes are expanded on both sides of the sheet. The copper ferrule is omitted at the smoke-box end, as the liability to leakage there is not very great; but at the firebox end, where the heat is more intense, it is of great service in preventing leaks.

The frames, in the meantime, have reached the shop, and are now swung into place. The two front rails, one of which is placed above the cylinders, and the other below, are bolted to the main frame, which is supported, at its rear end, by means of jacks. As the frame is the backbone of the locomotive, it is very important to have it accurately located. To assist in this a line is run from the center of the low-pressure cylinder exactly through its axis, and is secured to a standard placed beside the rear end of the frame. The frames are adjusted, by means of the jacks, until they are in exactly the right position when referred to the center line of the cylinders.

Attention is now directed to our engraving, which shows a rear view of the engine after the frames have been leveled and the guides and guide yoke are in place. This illustration clearly shows the general shape of the firebox, which is of the "modified Wootten" type, without a combustion chamber. The outward flanging of the back head is noticed; also the location of the two furnace doors. The mud ring is single riveted, and the front is dipped toward the center. The frame for a steam gage, placed so that the fireman can constantly note the pressure, is shown secured to the back head. There are many things about a firebox of this type which recommend it. A thin fire can be carried, without danger of blowing the fuel off the grate, very inferior coal can be burned successfully, and the evaporation per pound is increased owing to the more economical rate of combustion. A large firebox, with ample grate area, should mean plenty of reserve power so far as ability to burn coal is concerned; and engines of this type can usually produce plenty of steam when being worked to the limit on the road.

Simultaneously with the inserting of the tubes, more or less work is being done on the boiler in the way of drilling holes for bolting on the running-board brackets, air-pump frame, and other fittings. This work is done by hand, the tools being held by chains which surround the barrel. In the meantime, the boiler has been secured to the frames by a heavy bearer in the form of a girder, which is bolted to the mud ring on both sides, at the middle length of the firebox; the front and back water legs being also secured to the frames by means of steel plates.

This stage having been reached, the next step is to get the driving wheels in place. The wheels, as they come to the erecting shop, have the journal boxes on the axles, the eccentrics being loose on the main axle. The wheels are placed on a vacant track near the engine to which they belong, and are spaced about the right distance apart. The boiler and frames are now swung over by means of one of the large cranes, and lowered down on the wheels; the clamps, which act as braces between the pedestals of the frame, being first removed. These clamps are hollow, and are held in place by a long bolt which passes through them and through the pedestal on either side, and secured by means of a nut. The bolts are withdrawn and the clamps knocked out. The boiler is now lowered, and the journal boxes guided in between their respective pedestals. The clamps are again put in place and the engine raised about a foot above the ground, and set upon jacks which are placed under the frame.

The appearance of the engine is now as shown in our engraving. The guides and guide yoke are in place, and the crosshead is in the guides. The center bearing for the truck, a heavy casting, is shown bolted in between the front rails of the frame; the truck itself being one of the last things assembled before the engine leaves the shop.

By this time, nearly all the boiler-fittings are in place. The throttle pipe, with its valve, is lowered through the opening in the dome ring, and secured to the dome by suitable braces. The dry pipe has fitted to its front end a casting with a conical seat, which is ground into a similar seat in the front tube plate, to insure a tight joint. The front steam pipes in the smoke-box, which are of cast iron, are put in place, and the various wash-out and cleaning plugs inserted.

The boiler is now ready for the water test. The blow-off cock is connected to a suitable supply, and water forced in until the pressure is one-third greater than the working steam pressure—in this case, to 267 pounds per square inch, the working pressure being 200 pounds. The leaks develop quickly, and the calkers work on the seams until the boiler is perfectly tight. The duration of the test depends upon the length of time required to make the boiler tight. An hour usually suffices for this.

The water test having been finished, the boiler is emptied and tested with steam at 220 pounds per square inch, or 10 per cent in excess of the working pressure. The seams and fittings are again carefully examined, and steam under full pressure is blown through the steam passages and cylinders. These tests are very carefully carried out, in order to prove, beyond doubt, that the boiler and all its fittings are in perfectly sound condition when the engine leaves the shop.

After the boiler has been blown out, preparations are made to run the engine before setting it down on the rails. The wheels are all "lined up," that is, adjusted to exactly the position they should occupy with reference to the center line of the cylinders. The connecting rods are set up, the link motion assembled, and the valves then set by means of trams until they show the amount of lead desired; after which the eccentrics are keyed to the main axle. Simultaneously with this work, the boiler is being lagged. Magnesia is used for the purpose, and it looks, from a distance, not unlike whitewashed boards. The boiler is encircled by wire hoops, to which the lagging is fastened by means of cleats. The back head is lagged down to the bottom level of the furnace doors—an admirable feature, and one that is becoming very common in modern practice. The cab meanwhile is placed in position, it having been entirely finished and painted before reaching the erecting shop. The painting of the wheel centers, frames, and other parts, has been carried on simultaneously with the rest of the work.

The coupling rods are not up, they having been previously assembled and the wheels turned over to see that they fitted properly. The object of the running test is to see that the link motion and valves are in good condition, and that the cylinders and stuffing boxes are tight; and to ascertain this, it is unnecessary to have more than the main pair of wheels connected. By the time the engine is ready to be run, the sheet-iron jacket has been put over the boiler. The jacket, as received at the erecting shop, requires no further trimming, and each section fits accurately in its place. The cylinders are covered with cement lagging, and cased with a suitable iron jacket.

The boiler is now connected to a stationary steam plant, and filled with steam at about 180 pounds pressure. The engine is then given three running tests—one with reverse lever in back gear, and two with the lever in forward gear. The performance of the engine is carefully noted, to make sure that the various parts are working properly. These facts having been ascertained, the steam is blown off, and the shop tests thus finished.

The work of erection is now rapidly pushed to completion. As the weight of the engine is carried by jacks placed under the frames, the axles of the wheels can be dropped down between the pedestals, and the spring rigging set up without throwing any load on the springs. The oil cellars are set in, to replace the temporary wooden blocks which were used to line up the wheels before the engine was run. In the meantime, the driver brakes are being set up, and the air pump and injectors, with their piping and other attachments, put in place. Hand rails, cab fittings, running boards, and the many small details which help to complete the locomotive, are rapidly assembled. The grates, which are of cast iron, of the rocking pattern, are set on suitable bearers provided for them, and the ash-pan is then placed under the firebox. The truck, which is of the swing bolster type, with radius bar, is put under by raising the front end of the engine with one of the large cranes, and then rolling it into place. The truck wheels are raised by the crane, the center pin being guided into its seat, and are then propped up on wooden blocks, until the truck springs have been equalized with those over the front axle by a heavy equalizing lever, which has its fulcrum under the cylinder saddle casting. The engine is then lowered once more, and the pilot bolted to the bumper beam.

The engine is now ready to leave the shop. Before putting on the lagging it was moved by the crane to one of the main tracks leading out of the erecting shop. After being hauled outside, the finishing touches are put on and a final inspection made, the engine appearing as shown. The locomotive, when shipped, is stripped of its connecting and coupling rods, smoke stack, headlight, and a few other fittings, which are packed in cases and assembled after it is placed on the tracks of the purchasing company.

The time required to erect an engine varies considerably, but, unless materials come in very promptly, it is usually at least five or six days after the boiler is set up before the engine is ready to leave the shop. The exact way in which the work is done depends somewhat, of course, upon the order in which material is received; but the description given above may be taken as fairly typical of the usual practice.

The finished locomotive, ready for the road, is shown in our engraving. The two most conspicuous features of this design are the compound cylinders and wide firebox. The latter is unusually large for burning bituminous coal, the grate being nine feet six inches long by eight feet wide, giving an area of seventy-six square feet. There are 247 tubes, two and one-half inches in diameter and fourteen feet ten and one-half inches long, which provide 2,148.3 square feet of heating surface; which, with 185.7 square feet in the firebox, gives a total heating surface of 2,334 square feet. The ratio of grate area to heating surface is thus as 1:30.7. This, when it is remembered that in some narrow fire-box engines the ratio approaches and even exceeds 1:100, seems most unusual. The boiler is seventy inches in diameter, and the steam pressure 200 pounds.

The high and low-pressure cylinders are respectively fifteen and one-half and twenty-six inches in diameter, the common stroke being thirty inches. The driving wheels being fifty-four inches in diameter, the tractive effort, according to the Baldwin formula for compound locomotives, is 36,390 pounds. The total weight is 186,500 pounds, and the weight on drivers is 166,950 pounds. The tank capacity is 5,000 gallons, and the combined weight of engine and tender 286,000 pounds.

Taken altogether, the design is an interesting one, and the combination of a wide firebox and compound cylinders will doubtless give a good account of itself, especially when using an inferior grade of fuel. In the two particular features just mentioned, the design is quite in accord with the most up-to-date tendency in locomotive construction.

We have now traced, rather briefly, the progress made during the manufacture of some of the more important parts of the locomotive, as those parts are gradually converted from the raw material into the finished product. The length of time required to complete an engine varies largely according to circumstances and conditions of contract. Two or three months may, perhaps, be taken as an average. The shortest record at the Baldwin works is eight days, a narrow gage locomotive having been actually completed within that time. Perhaps the most striking feature connected with the work is the evidence that, in modern American locomotive construction, *utility* is the great object kept in view. Unnecessary finish is dispensed with, and the result is an engine that is strong, serviceable and practical, of moderate price, and able to do its work well until it is sent to the scrap heap to make way for something better. May the American locomotive continue, for all time, to maintain its high reputation, and to keep in the front rank of the motive power of the world.

In conclusion, the writer desires to express his thanks to Messrs. Burnham, Williams & Co., for kindly rendering every assistance in the preparation of this article.

THE JIG HABIT IN AMERICA.*

By OBERLIN SMITH.

THE subject we have in view deals not only with those tools known as jigs, but with analogous tools of various kinds which are used for cheaply reproducing certain predetermined shapes and locations.

The grand principle of the reproduction and duplication of artistic and utilitarian forms, the originals of which were the direct embodiment of the careful thought of the artist and the engineer, is, in some manifestation or other, almost as old as the world itself.

The most obvious, and perhaps the earliest, application of this principle was doubtless seen in the molding of plastic materials which could be afterward hardened, as clay, soft metal, etc. After the world had long been accustomed to the use of molds of various kinds, the products of which could be numerously duplicated, the most notable application of the general principle which appeared was undoubtedly shown in the art of printing—from permanent engravings and afterward from movable types. Other instances of this principle may be seen in the making of chromos and other lithographs; in the use of stencils; in the coining and stamping of metals by the use of presses and dies; and in casting metals and other substances.

A further application, differing somewhat in principle, may be seen in the use of turret lathes and similar devices, where cutting tools are arranged for an exact repetition of their proper location, to avoid hand adjustment for each piece of work to be operated upon. A somewhat similar principle may be seen in profiling and pattern-turning machines, so called, where the movement of cutting tools is governed by their being made to follow a master model of the work to be produced. Another instance of the same principle is seen in Jacquard looms and other weaving machines where a pre-arranged design, fresh from the soul of the artist, is duplicated numberless times by the use of automatic machinery, attended by cheap labor.

Still another application of the principle, and one in which we are more interested this evening, is the use of gages, templets, cradles and jigs, these being chiefly used in the paring and cutting, to exact finished shapes, of pieces of metal which have been more roughly formed by the processes of casting or forging.

The functions of a cradle and jig are sometimes combined with those of the drilling or boring machines in which they are used, in the shape of a special machine which is fitted for one purpose only and which is adapted for locating the work to be operated upon, as well as the tools, in absolute predetermined positions. A good illustration of such a machine is seen in the special multiple-spindle driller which is used for boring, counter-boring, facing, reaming and tapering all the holes in a mowing machine frame, at one operation, with the assistance of cheap labor. This machine works with sufficient accuracy for the purpose, and in one-tenth or one-twentieth of the time that would be required by ordinary methods with good machine tools and high-priced workmen.

Speaking first of gages, which are well enough known to make a detailed description unnecessary here, even were there time to treat of the numerous forms in which this tool appears, their general function is to inspect and verify standardized measurements. In accurate work, limit gages (so called) are frequently used, one representing the maximum and the other the minimum sizes, which are allowable, the work varying between these limits at different times and to different degrees, such variations obviously representing human fallibility when attempting absolute accuracy. The purpose of a gage is usually not so much to locate the position of various finished surfaces in a piece of work, as to inspect them and report upon them after they are so located.

Going a step farther, we have tools known as templets, which are usually flat pieces of metal (often thin sheet metal) which are laid upon various surfaces of the work, being located by the eye or by proper flanges, pins, etc., certain edges of the templet, interior or exterior, being used to rest a scriber, or other pointed marking tool against, while marking the position of exterior edges, or of holes or grooves to be cut below its general upper surface. Such a tool will, of course, reproduce marked lines with considerable accuracy, but the drilling or cutting to these lines afterward is subject to various errors, depending somewhat upon chance and somewhat upon the skill of the operator. If we make a templet thicker than usual and fasten it securely to the work, using the locating edges for the actual guides for cutting tools, we have the simplest form of flat jig. When the exterior edges of such a jig are used to locate finished edges in the work, the tool is often known as a filing or milling jig, as the case may be. By far the most usual function of a jig, however, is to locate cylindrical holes of various sizes and kinds as made by drills and other boring tools. The simplest form of flat jig is usually a plate of steel with certain holes accurately drilled through it at right angles to its upper and lower surfaces. If these same holes are to be drilled in a rectangular block of metal, for instance, of the shape of an ordinary brick, then it is obvious that if the same is laid upon the horizontal table of a vertical drilling machine, with a jig clamped upon the top of it, the external edges being made to coincide by the sight or feeling of the operator, the holes in the jig may be exactly reproduced, as regards location, in the piece of work—provided the drilling tools fit the holes in the jig without shaking. Furthermore, these drilled holes may be made of any desired depth by proper adjustable stops to limit the downward motion of the drill spindle.

In practice, such a jig as is above mentioned is often made somewhat in the form of a box lid with downward projecting flanges or pins to slip over the work, so that it need not be located by hand. Sometimes clamps, screws, or other fasteners are used upon one or more sides of such a jig to pull it over in one direction, so that it may be located by certain fixed edges of the work which are the most suitable. Should the work vary somewhat in size, as is the case with rough castings or forgings, it is sometimes desirable that the clamping should be central and should be done from all directions, somewhat after the manner of a universal chuck. A jig of this sort may in general be called a lid jig.

Carrying developments still further, we have the box jig, which stands upon its own bottom, so to speak, and into which the work is dropped and clamped in various directions, sometimes by the action of closing the lid—which may be hinged or otherwise secured thereto. If it is desirable to drill holes variously located and parallel to each other, in one direction only, through the piece of work in question, the jig, of course, always stands upon its bottom. It may, however, be required that other holes in other directions shall also be drilled. Thus, it is often the case that a jig, if of an approximately cubical shape outside, is turned over upon several or all of its six sides, the holes being drilled, of various depths, from any of the six directions, represented by lines normal to the various sides of a cube. Should still other directions be required, the outside of the jig can, of course, be made with various working "bottoms" upon which it can be temporarily laid. These can be at any desired angle with each other, and each is, obviously, placed opposite to the surface where the holes are provided for the drill to enter.

One of the most common illustrations of the use of jigs of this sort is found in the drilling of sewing machine frames, where the work usually consists of an iron casting of very irregular shape. Being dropped into its jig, it is located by certain surfaces which are most favorable for producing uniformity; in some cases some or all of these surfaces being previously finished by milling, or otherwise. This jig is then slid along upon the table of a gang drilling machine, each spindle of which carries the proper tools for drilling, boring, reading or tapping certain holes. The downward stroke of each tool is governed by a proper stop, and thus, by cheap labor, any number of accurate holes may be located and drilled in rapid succession by a proper manipulation of the jig, it resting on any desired bottom and being pushed along from one drill spindle to another. In

* From the Journal of the Franklin Institute.

such case the work is, of course, not disturbed in its position in the jig, during the complete operation in question.

In some cases a simpler form of the above-named jig can be used, the general shape of which is a flat plate with various legs projecting downward. Its general form may appropriately give the name of stool jig to a tool of this kind. The work is placed between the legs and clamped up against the plate, not having a proper bottom of its own on which to rest, as is the case with the lid jig.

Another modification of the box-jig may be known as a skeleton-jig, which, instead of having complete sides inclosing the work, is made in the form of a light skeleton frame. This tool is often necessary in heavier work than that above described, where it is desirable to save weight as much as possible in order that the operator may be able to easily handle, unaided, the combined jig and work.

It is obviously impracticable to treat heavy castings, such as the beds of lathes or the frames of large presses, in the jigs above mentioned. In such cases it is well to do the turning, milling and planing by ordinary methods, locating the finished surfaces by various gages and templets, after which local jigs, as they may be called, are applied for accurately locating holes by some of the finished surfaces already produced. These jigs are made to suit one or more holes, as the case may be. Being small enough to handle conveniently, they may be placed in succession on various parts of the large piece of work in question.

In making large jigs a very important point is to make them light for easy handling, but yet to get the utmost stiffness possible by very careful designing, that they may not warp, bend or twist when fastened to the work, thus throwing the holes, etc., out of place. It is usually best to use cast iron for the frames of jigs, because the working parts will maintain their position unless strain enough is brought upon them to actually crack the casting. Jigs, on the other hand, made of forgings, steel castings or brass castings are apt to bend without its being known, thus destroying their accuracy and perhaps spoiling large quantities of work before the error is discovered.

In jigs for accurate work, and where large quantities of pieces are to be made, all holes should be bushed with hardened and ground steel bushings, made to standard external diameters, that they may be easily replaced when their interior surfaces are worn by drills or other boring tools which revolve therein. In jigs for making work in large quantities these bushings are usually securely fastened in place, but so that they can be knocked out when too much worn. In other cases, where the jig is used for larger work and has to perform upon but fewer pieces at a time, interchangeable bushings are often employed, a full set of them being kept in the tool room which can be used at random in various jigs.

Cheap jigs for a small quantity of work are sometimes made by drilling the working holes through the body of the cast iron of which they are made. These, of course, are durable only to a limited degree. In some cases, instead of bushing each hole, a hardened steel plate, with the proper working holes drilled through it, is fastened to the framework of the jig proper. One difficulty in this system, however, consists in the fact that the warping of the steel in hardening is apt to somewhat displace the holes in their relation to each other.

The title of this lecture implies that there is a state of mind and a state of practice known as a "jig habit."

The tendency to use not only jigs themselves, but analogous tools embodying the same grand general principle, for the accurate and rapid development of interchangeable parts of machines and other structures, may be termed a habit of mind. Why this mental condition is prevalent in certain places and with certain people more than at other places and with other people is a question for the psychologist. That it does exist to a greater extent in North America than in other countries in the world, and that it is found more especially in that class of Americans (no matter where they are born) whom we may term "Yankees," is, I think, an indisputable fact. These people are of a class who are born to be mechanics, and who have been brought up in an atmosphere permeated with intense practical energy.

The American who possesses this habit (usually both born and acquired) seems to have been developed during the last hundred years or so by reason of coming, in the first place, from good English and other European stock in whom common sense is a chief characteristic. The evolution of the jig habit seems to have come from these men being cast upon their own resources in a new country, where novel and original methods were often forced upon them, and where much freedom of thought and action enabled them to study for themselves methods which would allow them to carry out their mechanical ideas upon the most economical basis—not only for the love of the money to be procured thereby, but from an innate love of mechanical things put into their simplest forms.

[Continued from SUPPLEMENT No. 1357, page 21748.]

THE PRACTICAL BUILDING OF LOWLAND PROTECTIONS.*

By PERCY H. WILSON.

TIMBER PROTECTION.

THE idea of timber protection is almost as old as that of the mud bank itself. Timber being plentiful, it has generally been used.

These crib formations are a good protection, and may be made very substantial. They are, however, liable to decay, particularly the portions between low and high water, the natural life of such a structure being about five years. Then repairs must be made, and the cost of such repairs is in proportion to the stability of the original structure; the better the original, the greater the cost of repairs.

The oldest method in existence is the piling of cord wood perpendicular to the length of the bank, and in front of it (Fig. 10). The pieces are usually ten feet in length and about four inches in diameter. They are laid to within two or three inches of the top of the bank, the ends being firmly driven into the bank, as good a bond as possible being effected between the bank and the wood. In order to prevent the sticks rolling, they are piled in sections, very much like ordinary cord wood. A solid row of vertical pieces is driven into the marsh perpendicular to the length of the bank, another row similar being driven parallel to them at a distance of about fifteen feet. The space between is then filled with the horizontal logs, the vertical row keeping the horizontal ones in position.

At first glance one would say that this construction was of little or no avail, the speedy decay of the wood and the washing of the water, which will certainly penetrate to the bank, probably effecting a speedy disappearance of the protection. This is not the case. Upon examining one of these protections which had been in place for twenty years, it was found to be in apparently good condition. The wood for about a foot, at an elevation corresponding to three feet above low water, was pretty badly decayed, but had formed a layer of dirt which at that point made the bank really ten feet wider than the bank proper. Otherwise the bank was intact, and apparently in as good condition as ever. Earth is at times piled on top of the protection to help keep the logs in place.

A protection very generally used on small banks is the driving of upright sheet piling. These, if driven without guides on top and at low water, and also if they are not plowed and grooved, are of very little value, the filling washing from between the openings in the board. A heavy log is fitted with handles, and, several men raising it, it is allowed to fall on the head of the timber and drive it to place—a very tedious and expensive operation.

A method of protection used extensively in the creeks of New Jersey is that of a row of cedar poles driven in the marsh about twenty feet in front of the bank, being about four inches in diameter and twelve inches c to c. These poles break the waves caused by wind, which are likely to erode the bank, and render the water coming in contact with the bank quite smooth.

This brings us to the more elaborate forms of protection which end in bulkheads. It is not my purpose to go into bulkhead work, although this is but another form of bank protection. I will, however, give a sketch of an excellent form of protection, practically a wharf, which is very generally used (Fig. 11).

Description of Design.—Piles are driven for a foundation, the first three being sawed off ten inches above low water, and two clamp pieces 4 x 10 inches—10 feet placed on either side of them. Above this is placed a cap-piece, 4 x 12 inches—10 feet, extending over the first three piles. To this cap the flooring is spiked, running parallel to the bulkhead. At the inside end of the clamps and cap-pieces the sheet piling is driven. This piling should in every instance be driven to a firm bearing, so that, no matter what the wash or strain upon it, there would be no danger of shoving out at the bottom.

Two other rows of piling are placed back of the first three, and are sawed off to a level a few inches below

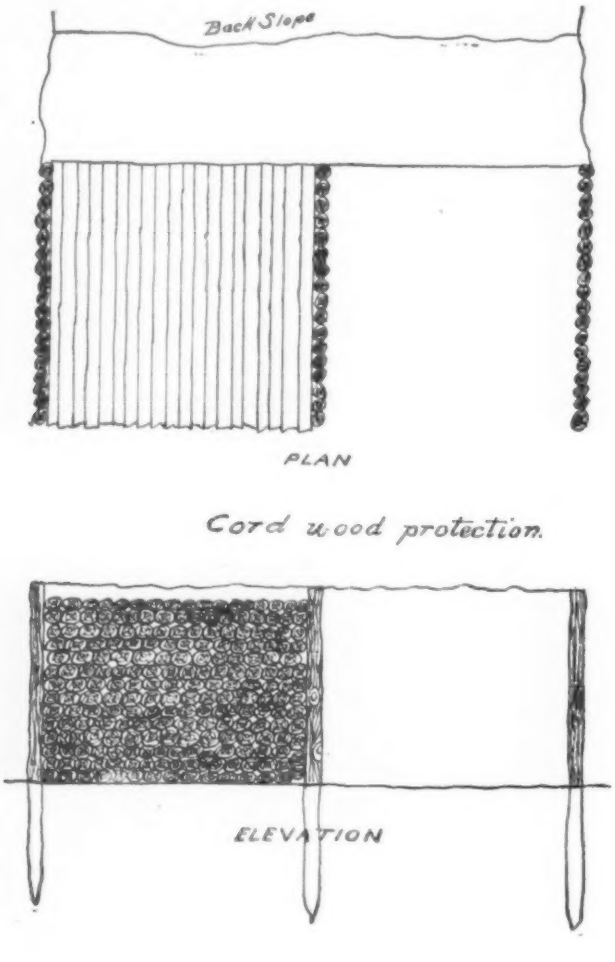


FIG. 10.

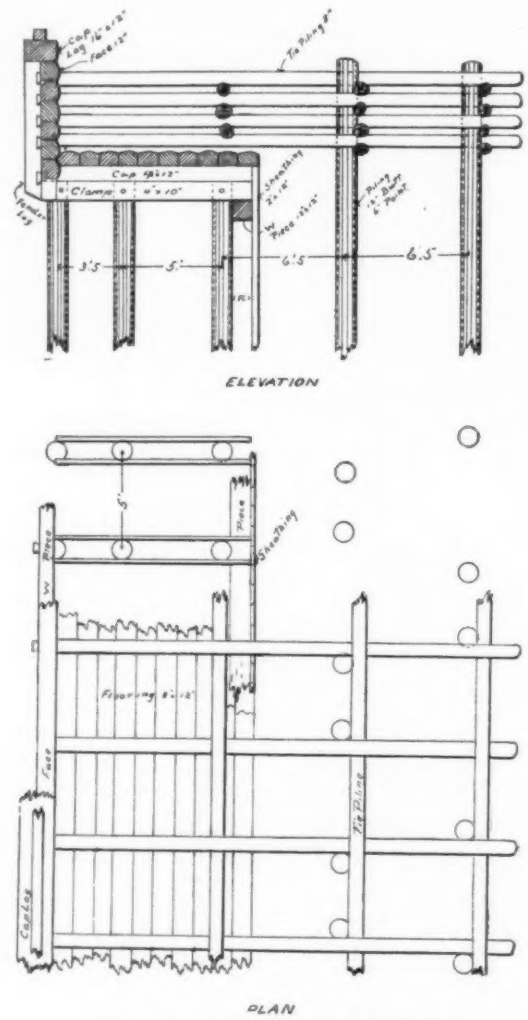


FIG. 11.—BULKHEAD PROTECTION.

* This paper is an abstract from a thesis presented to the Civil Engineering Department of the University of Pennsylvania, for the degree of C. E., and is reprinted from the Proceedings of the Engineers' Club of Philadelphia.—Read September 21, 1901.

the top of the bulkhead. These are called tie piles, to which are fastened the tie rods running through notches in the bulkhead. These ties are on the same line longitudinally, but are alternately first on one side of the tie rods and then on the other. The rods are saddled, i. e., rounded out to fit the piles snugly. The position of the piles assures a straight rod, and, when bolted through and through, they form a construction which should never give. In addition to this, longitudinal piles are laid between the rods and behind the tie piles, being bolted securely to both. The bulkhead itself is built of twelve-inch stuff, faced on three sides, rough in back, each course being drift-bolted securely to the course below, in addition to which the ends of the tie rods are securely bolted to the bulkhead timber. It will be noticed that the tie rods are placed between two bulkhead pieces, thus cutting away only a little of each piece of timber and saving its strength.

CONCRETE WALL.

The building of a wall, either one of concrete or of stone laid in cement, furnishes by far the most efficient and permanent protection. Rather than generalize on the subject of these protections, I have chosen two examples, which I had the opportunity of watching during construction.

General Description.—The wall is situated at one end of a great fresh-water reserve basin, under construction at the present time, and is of concrete and on a pile formation. It is parallel to and thirty-nine feet from the line of an old causeway, which was protected by crib work. In designing the wall, the following contingencies had to be met and overcome:

1. In order to place the wood construction below the plane of mean low water, and also to permit the pile-driver to work at all stages of the tide, it became necessary to remove, to a depth of about seven feet, the mud from the site of the work (Fig. 12).

2. At a distance of fifty feet from the face of the wall there was to be made a depth of twenty-five feet at mean low water, making a slope of 2 on 1 in front of the wall. The piles, therefore, must be brought to such a depth as to make the foundation safe against sliding when the material was removed from in front.

3. The open space between the new wall and the old causeway was to be filled with dredged material; therefore the foundation as well as the wall had to be designed to bear the great thrust of this material.

Details of Design and Construction.—In all permanent constructions exposed to tidal action the wooden portions of the structure must be below, or very nearly at the plane of, mean low water; and when thus placed, are as good as any other known construction and much cheaper than some. The material was excavated to a depth of two feet at mean low water by means of a grapple dredge with a seventy-foot boom, being thrown over along the line of the cut and also at one end. The cut was made one hundred feet in width to allow: (a) A slope of two on one to prevent the material from caving into the cut; and (b) for the construction of the foundation and a width sufficient to allow the pile-driver to drive the first line of piles under the wall, head on.

Upon the completion of this work, the engineer expected to use the banks thus formed as a coffer-dam, putting sheet piling across one end, and with pumping plant keep the level of the water inside the dam below the level of the pile heads, thus enabling the work of placing the clamps and flooring to proceed without tidal interruption. This idea was finally abandoned, owing (1) to the extreme softness of part of the material excavated, it being thoroughly unfit for the contemplated use; (2) to the expense of moving the pumping plant to the site of the work, and maintaining the same; and (3) to the leakage of the old causeway, the water having cut channels through the filling of the crib until with every tide, water flowed through in streams, with little or no opposition.

DIFFICULTIES OVERCOME.

1. It was difficult to keep the material cast up in place, owing to its softness, and also the large amount of material to be excavated (twenty yards per running foot of cut), all of which had to be placed on one side. Several slips occurred, the material breaking away from the center of the bank and sliding back into the cut. When a slide of this kind occurred, it was left until the last, when on one high water it was thrown behind that material originally excavated and no more trouble was experienced.

2. In order to drive the piles to a sufficient depth to insure the proper stability against the foundations' sliding, seven feet of hard gravel were to be driven through, besides the mud. Borings made by means of a jet showed mud to fifteen feet; a thin layer of sand, with gravel below to a depth of thirty feet, the depth to which the borings were taken. The piles were supposedly driven to a depth of about twenty-two feet mean low water. An ordinary pile-driver with a drop-hammer was used, the weight of the hammer being twenty-seven hundred pounds. The piles were unshod and driven unpointed. Judging from the condition of some piles driven on a later contract near the site of the work, and drawn, there is no doubt that the ends were very badly "broomed" for a distance of at least three feet. This, however, did not endanger the bearing power, as there is more than enough to support the weight of the wall and filling. The piles were of yellow pine, thirty feet long, not less than twelve inches in diameter four feet below the top, and six inches at butt without the bark.

Construction of Foundations.—The piles were driven with a wrought-iron band, each pile being sawed off fair at a height of eighteen inches above mean low water and the bands driven one and a half inches below the top. On top of the piles, and securely spiked to them, were cap-pieces 12 x 12 inches, extending the entire width of the foundation. On these caps the flooring was laid entirely over the foundation structure, 4 x 12 inches yellow pine being used, and securely spiked to the caps. Before this flooring was put in place, the space between the piles was filled with dredged material up to the level of the top of the caps, the idea being to prevent the washing out of the fill through any possible holes in the floor. The sheet piling was placed at the back of the foundation, and was of three kinds (Fig. 13).

(A) The strips for the plowed part were first put in on one pile and nailed securely in place, the next piece of sheeting being then driven. The piles themselves were 12 inches by 12 inches with a two-inch groove, the strips being of cedar, which when wet swells, insuring a tight joint.

B and C are both yellow pine. Of the three kinds, C is the least expensive, but not so effective as A.

STONE WALL.

Owing to the low elevation of the ground in front of an old bank, it was decided to construct a stone protection wall about one hundred feet in front of it, feet, and was supposed to be spiked to every piece of sheeting. When the spikes were tried, it was found that they split the hemlock sheeting, and it being too expensive for the contractor to bore proper holes to receive the spikes, this part of the operation was omitted (without the knowledge or consent of the parties having the work done). The contractor at once realized that the sheeting with no fastening was practically useless, and thoughtfully substituted three-foot lengths instead of fifteen, as called for in the plans. There being some doubt as to the low-water line (in the mind of the contractor), the piles, instead of being sawed off ten inches above low water, were sawed off eighteen inches above. This gained him sixteen inches of tide in which to place his clamps, floor, and

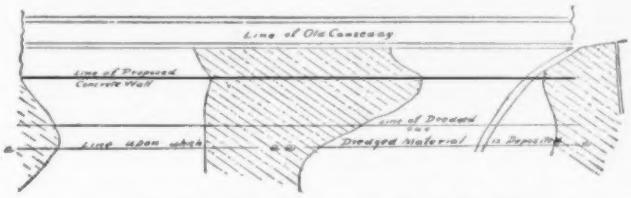


FIG. 12.—POSITION OF CONCRETE WALL.

filling in the space between the dredged material taken from in front of the wall, thus reclaiming the land.

If the stability of the wall was calculated to withstand the thrust of this material, serious mistakes were made, as the wall is a miserable failure. A depth of about five feet of material was excavated from the site of the wall to allow the sawing off of the piles at the proper height and the subsequent placing of the clamps and flooring. The ditch was made wide enough to permit the pile-driver to operate "end on the wall at all stages of the tide." As much material as possible was thrown on the inside of the line of the wall, the remainder of the material being placed on the outside line of the ditch.

The piles were then driven and caps placed, the sheeting being left until the last. The caps and flooring were placed at low water, and then the stone laid in cement, the various courses being laid alternately at high and low water. Finally, the space behind the wall was filled in with material dredged from the front.

Details of Design.—The foundation consisted of three rows of piles, three feet center to center and ten feet center to center respectively. The tops of the piles were trimmed away, leaving only four inches width of the original head, allowing the clamps to fit neatly, the back or so-called row of tie piles being treated in the same way. This was a mistake in the design, as it left only four inches of wood where there should have been ten inches, thus very much weakening the construction. The sheeting consisted of 2-inch hemlock, and was placed on the outside with only a 3-inch by 6-inch wale-piece to hold it in place. This wale-piece was spiked to a pile every five

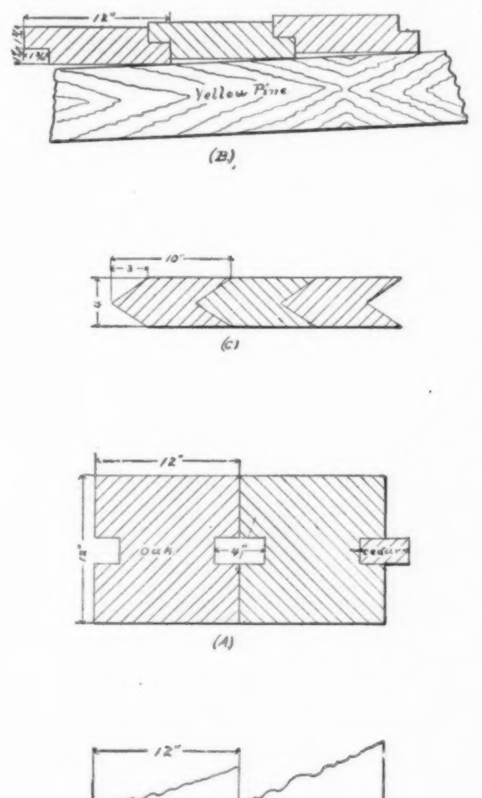


FIG. 13.—CROSS-SECTIONS OF SHEET PILING.

lower courses of stone, and also saved him 2.66 cubic feet of masonry for every running foot of wall.

The flooring was placed as the specifications directed, and the wall was built nearly in accordance with them. The stone was of the specified size.

Upon the completion of the wall, material for filling was placed inside, and, although very little was put in at one time, the sheeting promptly pushed out at the bottom, being finally left in the shape shown in Fig. 14; and as the filling was continued, the whole structure, foundations and all, moved to meet the sheeting until the condition of the wall is about as shown.

The wall was accepted, the failure being attributed to weakness of design.

Duties of the Engineer.—The duties of an engineer employed upon this class of work being somewhat analogous in all the above works, I have left till the last a description of these duties, and shall consider all the sections under one head.

On mud revetment work an engineer is very rarely employed, one of the bank managers, a farmer usually,

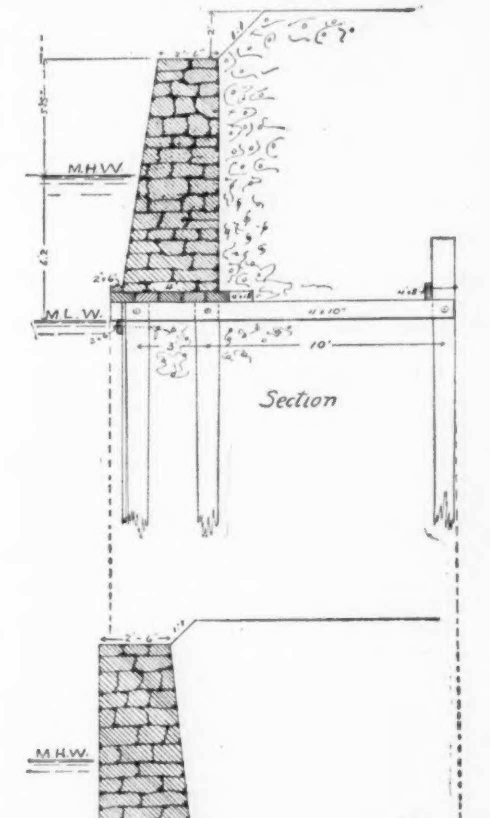


FIG. 14.

being given charge of the work. As he has to look after his farm and the bank at the same time, the bank is usually left to the supervision of the contractor, and finally accepted as a whole upon completion. This is really a much better way than at first thought it would seem. The grade and width on top with slopes may be very nearly judged by any one at all familiar with bank work. The other most important points in bank building—viz., to leave enough "berm" between the cut and foot of bank, and not to pile more material on the meadow than it will bear without breaking—may be safely left to the contractor. The sliding in of

the piled-up material due to either of the above causes is so disastrous to the contractor that, for his own protection, he will give these points careful attention. Again, from his experience he will be much better able to judge the bearing power of the meadow, and the proper amount of berm to be left.

If stone protection is to be used, careful supervision should be given to the laying of the stone. Speed is requisite to the profit of the contractor; and the greater the speed, the more careless the placing of the stone. A good firm backing should be insisted upon, the stones to be pressed into this three or four inches. Each course of stone should have a firm bearing upon the course below. The line of batter should be carefully carried out, for, as explained above, on this depends to a great extent the lasting quality of the wall.

In bulkhead protection the services of an engineer are almost indispensable. All the timber and iron work should be carefully inspected. The lines for driving the piles and the elevation at which they should be cut off should be given by the engineer, and permanently marked to enable reference at any moment. Finally, a careful supervision should be given to the actual work, and the following points watched with great care, for therein the contractor generally faileth:

1. Careful record should be kept of the material used in the construction, to make impossible the substitution of other for that inspected. This should include a careful list of all material brought upon the site of the work by the contractor.

2. Care should be taken that the piles be cut off at the required height.

3. Every precaution should be taken to insure the driving of the specified length of sheeting.

4. The fastenings, whether bolts or spikes, should be inspected when in place, and under no circumstances should work be allowed to be covered up until inspected.

The above points apply equally well to concrete and stone wall protection, except that in these cases is added the careful inspection of the mixing of the cement or concrete, as the case may be, and the testing of them.

In my opinion, the most reputable contractors need as much supervision as those of unknown honesty. Workmen are prone to fall into the easiest methods of accomplishing the work, and often, entirely without the sanction or knowledge of the contractor, perform the work in ways far from those specified in the agreement and plans.

The highest duty of an engineer is to exact justice, not only from the contractor, but for the contractor. He is a middle-man, and should use his best judgment in interpreting and carrying out the specifications. Often the engineer is too narrow to do anything but nag and in every way annoy the contractor, thus instead of assisting and working with him, really retarding the work; in the mean time incurring the dislike of the contractor, who then tries to hoodwink him at every turn. The above points are only a very few of the engineer's duties, but loom up in the practical end of the work. They will apply almost equally well to any kind of construction work, although every piece of work is surrounded by local conditions, which may change in every way not only the duties of the engineer, but the kind of construction and the methods of performing the work.

THE POSITION OF THE ENGINEER IN MUNICIPAL SERVICE.*

Address by ALEX. DOW, President Detroit Engineering Society.

THE Detroit Engineering Society has always avoided any semblance of political action. We have at times discussed matters of engineering interest so closely akin to what we recognize as politics that our discussion took a distinctly political tinge, but the tendency of each discussion was toward the education of our members as individuals and away from any action or even expression of opinion by us as a society. In choosing the subject of this presidential address I have not forgotten our laudable custom. The intent of this discourse is educational. It is based on personal experience and observation as an engineer, and is offered to you as engineers in the belief that it will be of interest and perhaps of service.

You will find my text in the Detroit Evening News of April 5, where one of the Public Lighting Commissioners is quoted as saying, "I used to think that municipal ownership was a good thing, but my experience has taught me that it is impossible to divorce public business from politics. It is all politics, and just now the Public Lighting Commission is composed of two Republicans and four Democrats."

It is quite true that the Public Lighting Commission is suffering from politics—Democratic politics, labor politics, reform politics, and just enough Republican politics to season the mess. I suppose the labor men and the reformers object to being called politicians. Perhaps they are not such. Perhaps they are merely playing at being politicians—you know the tale about the man who thought he played poker, but really didn't—but they are partisans; and it is not the politician, in the honorable sense of the word, but the "offensive partisan," to use the expression invented by Grover Cleveland, who is a discredit to politics. The man who in public service endeavors to represent or to serve a faction instead of to represent or to serve the whole body politic is an offensive partisan. What his faction is or calls itself is a matter of no consequence. He may represent the Good Government League, or the Women's Christian Temperance Union, or the Associated Charities, but when he announces that his service as a commissioner or his employment as a subordinate of a commission is in the interest of, or as the special representative of, any part of the people, and not all of the people, he is a partisan.

In my experience the most offensive partisans have been those who claimed to represent moral agencies. When they were honest, they were doctrinaires; when they were dishonest, their dishonesty overpassed exceedingly the dishonesty of the politician who admits that he is a politician. My experience is not peculiar. A friend of mine who has paid for his knowledge of city councilors in an Ohio city, where there is an organized reform party, tells me that the only difference between Democrats and reformers is that the reformers don't stay bought.

The common form of speech by which we express the offensive partisan is to call him a practical politician. This expression differentiates him from a man who takes an occasional whirl at politics because he has a momentary feeling that it is his public duty to do so. The practical politician calls that kind of a man a mugwump, and I think he deserves the name. I shall use the euphemistic expression in the remainder of this address, and you will understand that when I speak of the practical politician I am calling the person by the name which he has himself chosen.

The interest of the practical politician in any public department is primarily the money paid by that department as wages. The politician believes that the jobs belong entirely to him. He is even more interested in these than he is in the contracts which are given for supplies or for construction. On these contracts he and his friends can only expect a percentage of the profits, but he and his friends are ready to place their names on the payroll of the city for all the money in the treasury. Whether they can earn their stipends is immaterial. Of course, the work must be done by somebody, but the politician believes that if he and his friends are employed in sufficient numbers the work will be well enough done to keep the public quiet without any one wasting too much of his time and energy on the performance of the small part which becomes his share.

You must not suppose that the politician in office is an idle man. He is exceedingly busy—as busy as the devil in a gale of wind. The trouble is that he is not doing the work he is paid to do. He spends his time in promoting the interests of his party. He attends conventions, sometimes forgetting to get leave of absence, and always forgetting to have his name removed from the time-book. He is active at caucuses, and is a worker before election—a very hard worker. And when, after election, his wornout system requires repose he takes the same cheerfully; still omitting to notify the timekeeper of his absence from duty. The interference with the work he is paid to do is just about the same as if he went on occasional drunks. The only real difference is that his irregularities are exceedingly regular, being predetermined by the laws fixing the dates on which elections shall be held.

Public opinion has long ago officially and practically condemned the man who allows his pleasures to interfere with his duties, but public opinion has not yet reached the stage of practical condemnation of the man who lets his politics interfere with his doing the work for which he is paid by the public. When it is effectively recognized that politics and dissipations are on the same footing if they prevent a man from doing the work which he is hired to do, public service can be performed as cheaply and as efficiently as is private service.

When a practical politician holds an office which gives him the power of appointing other public servants, he attains his maximum power for mischief. He not merely fails himself to earn his salary, but he employs others of his kind with a distinct understanding that they are to justify their employment by work done in the interest of him and his faction. That they are supposed to make some kind of a bluff at filling the nominal duties of their offices is true, but the politician so appointed looks to his sponsor for protection in his idleness and does not in the least hold himself amenable to the taxpayers whose money he eats. He is not the servant of the city, but he is the "*man*" of such and such a boss. Sometimes the "boss" is a recognized party leader, and the appointment is made in the interest of the party. "The party owed me the job after all these years of work for it; I intend to take things easy and have a rest." That is how a man in this city, receiving such an appointment, stated the case, and he is even now resting at the public expense.

To return to my text. My experience is different from that of the commissioner quoted. It has taught me that it is entirely possible to keep public business separate from politics, even the public business of that very commission. My experience has led me to believe it possible to divorce public business from politics after the two have formed such an unholy alliance. To keep them separate in the beginning was the work of an engineer, and I now propose to tell how it was done. Hereafter I may justify my belief that the old condition can be restored.

The first Lighting Commission was absolutely nonpartisan. In its constitution there was the usual recognition of each of the great parties, but each of those six men stood for the whole city and never for a moment for his own political friends. That was as it should be. A bi-partisan board is not a non-partisan board. You cannot neutralize three aggressive Republicans by appointing three equally aggressive Democrats. Two blacks don't make one white, and the result in practice is at best a deadlock. If by any chance a Republican partisan votes with the Democrats he is called a traitor, and there is a howl for his political scalp.

This non-partisan commission decided that its duties were essentially legislative. Its members were business men who certainly could not give attention to details of commission work. You remember that these commissioners are unpaid; well, perhaps I should not put it so, but the payment they get is of the kind best described by a tale concerning our fellow-member, Mr. Frank E. Kirby, who served a term as a Water Commissioner of this city. The water board of a large Eastern city visited Detroit in the course of a tour in search of information. Mr. Kirby dropped his other duties to entertain the visitors, one of whom in conversation spoke as follows: "In our city there are three water commissioners; we each get $3,600 a year. How many are there of you in Detroit, and what do you get?" The answer was grim, but precise, "There are five of us, and we get hell." The first Lighting Commissioners were well paid in the coin named by Mr. Kirby. Some of them are, I think, still receiving small instalments of their salary. Be that as it may, they decided that their duties were legislative, and therein they made a wise decision. They sought as their executive an experienced electrical engineer of good administrative ability. They failed to be satisfied by any of the numerous applicants who asked for the position; they made guarded inquiries concerning a number of men who were engaged in such work as they had to do, and they ended by offering the appointment to a man who was about as thoroughly surprised as any one could be by such an offer. That was me.

From the beginning, the separation of legislative and executive functions was complete. The commission decided on a policy. I reported on and advised as to possible plans whereby that policy could be carried out. The commission authorized the execution of a general plan presented by me, and then it became my duty to carry out that plan, myself selecting the immediate agents and settling the details. On me lay the responsibility for results. Logically to me was given the choice of means.

Given full charge of the work and the force; given power to employ and discharge help; ordered positively to see that each employe earned his pay; to require no qualifications other than citizenship and competence; to disregard all indorsements which were not supported by own observation of the work actually done for the commission, it would appear that I should have been able to keep practical politicians out of the service of the Public Lighting Commission. Did I do so? Well, I think I did. I was convinced of it by the fact that the Republican politicians of the city condemned me for a Democrat, and the Democratic politicians cursed me for a Republican. That was at first; after a year or two they sized me up better. Toward the end of my service I had the expert opinion of a recognized authority on such subjects as to whether I had succeeded in organizing a non-partisan force. The authority was the Hon. Hazen S. Pingree. I think no one here will question his competence. The opinion was given to me personally, in explicit language, and at some length. I do not know that it is advisable to quote it in full or verbatim; indeed, my memory fails me. But the salient point thereof was, "You people down there at the lighting plant are political eunuchs." Now, really, I don't like being called a eunuch, and I think that the Hon. Hazen S. Pingree's metaphor is somewhat startling, but it is so thoroughly expressive that I venture to pass it on to posterity by embalming it in this presidential address.

How did I carry out my plan? Well, I began, so far as the laborers and mechanics were concerned, at the top of the long list, which was arranged according to priority of application. I called for these men in bunches, sized them up personally after the fashion of all engineers who have to hire men; you know how it goes; you don't have to be told that some men are not worth a continental; you can see that by looking at them. I questioned them as to their citizenship and previous experience, rated them according to their claims and set them to work. I personally hired each man, and the hiring was a big part of my work. In a short time I could tell whether or not a man was competent. If he showed himself such, he remained in the service. Some of the men employed in this way seven or eight years ago are still on the Public Lighting Commission's payroll. If a man showed himself incompetent, he was summarily discharged. The orders of the commission were that no man should have a time appointment; that each man should be hired from day to day or from month to month.

There was an application blank which had spaces for name and address, trade or profession, previous experience and references. The references were often autographic. The rule that a man should be a citizen and a *bona fide* resident of Detroit led to many of the applicants establishing their status by presenting the signature of one of the aldermen of their ward or some other well-known Detroit man. Our foreign-born residents almost always secured the alderman's signature before presenting their application. The rule as to local residence was not absolute, but (after my own name) there never was but one selection made outside of the city; that selection was Mr. Walter D. Steele, a former member of this Society, and who became my chief assistant and afterward my successor. Mr. Steele brought to my aid a knowledge of high-tension electric constructions, and particularly of underground cables, such as was not possessed by any Detroit man, and which was essential to the performance of the duties which fell to him.

In the original selection of employes many presented the indorsement of local politicians. During the first three years, which were years of very hard times, there was an unusually large selection of employes available. Capable tradesmen were glad to get work as helpers or laborers, and for every position, excepting those requiring special technical training, there were from twenty to fifty applicants. It would have been possible to fill each such place after turning down every man indorsed by a politician. That would, however, have been a mistake. A selection from men indorsed only by the "goo-goo" element of our citizenship would, I think, have furnished about as large a proportion of utterly useless and worthless employes as could possibly have resulted had none but pernicious politicians been chosen. Some of the poorest specimens of mankind that were tried in the service brought the most magnificent indorsements from preachers and from pillars of churches. I honestly believe the average preacher does not know the making of a decent workman. I must expressly exempt the Catholic priesthood from this reproach. I noticed that a man who referred us to his parish priest was almost always a good find. On the other hand, some of the best men whom I found, including men who are still employed by the commission, carried the indorsements of politicians whose reputations are far from saintly. I don't say that a tough alderman invariably recommended a good man for a job; what I mean to say is that, especially in these years of business depression, the tough aldermen could and did furnish from among their constituents enough mechanics and tradesmen, of a thoroughly reliable character, to fill any number of positions such as I had to offer. Of course the tough aldermen sometimes sent worthless men to me, but I had an effective method of dealing with such cases. If the man proved worthless, I summarily discharged him, and then I did not wait for his political sponsor to come to me complaining that his man had been "thrown

* From the Journal of the Association of Engineering Societies.

down." I made the announcement myself to the sponsor, and followed it up by a few well-chosen remarks in the vernacular which let him understand that it was his business to know that a man was a good, capable worker before he sent him down to the Public Lighting Commission, and that if the said sponsor did not know any better than to send such a damnable specimen as the one just discharged I would decline hereafter to consider any of his recommendations.

I commend this prescription to any one of you who may find himself in such a position as I then was in. The first dose, if liberal, effects a complete cure.

The places which required technical training were more difficult to fill. I have already mentioned that one place had to be filled by employment of a man from outside the city. The first draftsmen and inspectors were found by inquiry among the manufacturing and technical concerns in town. They were college men, and their coming to the service was followed by a succession of applications for employment from other college graduates, largely University of Michigan men. The names of most of those men have been on the roll of our Society.

The engineering staff of the construction period was formed of these young men, and when the operating force was organized a number of positions were filled from the construction staff. The pay of these places was not high—$75 per month being the standard. I could not expect to retain such men permanently at the salaries which were possible, but I could and did arrange for a continuous succession in office. There was no place which was not well filled, and behind each occupant of a place there was a possible successor; the final vacancy of the series being a draftsman's position, which could naturally be filled by any graduate of the engineering department of the University of Michigan. The plan worked during my term; the men have assured me that they found their Public Lighting experience of value, and I am proud to say that they are all to-day filling positions of responsibility with credit to themselves and to their earliest employment.

I see in the press that one of these positions, formerly filled by a graduate engineer, is vacant, and that a competent man cannot be had for the pay. Well, I think the trouble is that a competent man will not take the place under the present limitations. The pay is plenty, and if the place at the salary named were vacant in one of my plants instead of in the city plant it would be filled mighty promptly by an Ann Arbor man.

The steam engineers and similar expert mechanics were selected from the list of applicants. In these classes the plan of putting a man to work and seeing what would happen could not be tried with the same freedom as was permissible with laborers. An incompetent engineer might wreck an engine in demonstrating his incompetence; or an unskillful electrician send himself to paradise by the electric route, and thereby cost the city $5,000 or so. It is really remarkable how valuable such a man becomes after he is dead. But the method was modified only in degree, not in kind. A man was first questioned and then tried. His indorsements counted for nothing, his politics for less than nothing.

The relations of the plant to what is called "union labor" were very early defined. The first commission announced that it recognized citizenship and competence as being the only essentials for employment. It classed union labor affiliations together with politics and religion, as being immaterial so long as they did not interfere with the performance of a man's duties. It resulted that we made no inquiry as to a man's being union or non-union, and that naturally a large proportion of the men employed were union men. I think the ground taken in the matter was solid, and that it is the only ground which promises permanent freedom from trouble.

It was not sufficient to obtain employes who were free from political obligations. It was necessary that they should remain clear of such entanglements. Our rule in the beginning was clearly stated, and it was reiterated from time to time as occasion required. It was that every employe should have opportunity to vote at primary and regular elections; that there should be no inquiry as to how or for whom he voted, but that no employe should on any pretense engage in what is called party work. A report that an employe was making himself notable in politics caused him at once to be called on the carpet and notified that a persistence in such activity would surely lead to his dismissal. In the early days of the commission it was necessary, in more than one case, to warn men individually of the consequence which would follow their persistence in political activity. These warnings took the form of a statement that the Public Lighting Commission was non-partisan; that the retention on the roll of an active partisan of either party would lead to demands from the other party that some equally active partisan of that stripe should be employed; that the commission did not propose to engage in any such balancing of evils, and that therefore the employe must limit his activities or quit the service. No man was ever discharged for political activity. One man resigned with the friendly statement to me that he thought he could better himself otherwise by his political work, and that he therefore preferred to sacrifice his present job. Anonymous charges were occasionally made that men were discharged because of their politics, but the record was easily cleared. These charges were all made in the early days, when each party said I was a vile tool of the other party.

For five years—three years of my service and two years of my successor's term—the relations of the commission to its electrical engineer were unchanged. You will recognize that these relations were essentially those of a board of directors of a corporation to their general manager. In my own case they were exactly the relations which I now hold to the directors of the corporations whose property I manage. They were the relations which exist in every such department in every city whose work is well done and free from political taint. Instances can be multiplied not only of the successful operation of this distribution of duties, but also of the evil results following when any other distribution is essayed. The Chicago newspapers have just furnished an excellent illustration of success and of failure. The success is in the management of the South Parks. In the past and in the present the South Park Commissioners have performed precisely the duties of a directorate of an incorporated company. The name and title on their letter heads, "J. Frank Foster, general superintendent and engineer," means just what it says. Mr. Foster is general superintendent in fact as well as in name. The West Parks have been managed on the other plan. The commissioners have been partisans, and have appointed partisan employes. The general superintendent has too often been chosen for his efficiency as a party worker. The engineer has always been a subordinate, and too often a negligible quantity in the equation. I speak from knowledge, because I have done engineering work on behalf of each of these municipal bodies. The results of the two systems are summed up by the published cost of maintenance per acre of each system. The average cost of maintaining the West Side Parks is $498 per acre per annum. The average cost of the Washington Park is $220 per acre per annum. And those who know their Chicago and can mentally compare the two park systems will promptly agree with the newspapers that the conditions of the two systems are in the inverse ratio of the moneys spent upon them.

In Canadian cities the man in charge of public works is usually a civil engineer, and he is actually in charge. The Public Works Committee has legislative functions only, and a law duly enacted, not merely a ruling of a commission, prohibits the activity of any city employe in politics.

I have spoken of the successful operation of the public lighting plant, while the functions of the commission and the engineer remained clearly defined. It is now in order to tell what happened when this definition became hazy. After five years' operation of the plant, ill-advised economies, insisted upon by the board in direct opposition to the advice of the engineer, caused a strike of the arc lamp trimmers. The question of detail was whether the trimmers did or did not do enough work for their pay; whether, in fact, their duties were proportionate to their wages; whether they had what in the newspaper discussion at the time was called a "snap." I think the trimmers' duties were no snap, and I know whereof I speak. A man who trims sixty open lamps on a circuit of average length daily, Sundays included, summer and winter, in fair weather and in foul, in the early hours of the summer morning and in the bitter sleet storms of our winter and early spring, has no snap if he does his work properly. Electrical Engineer Steele told the commissioners this. They overruled him. Be this minor fact as it may, the major fact was that the commission, to secure a small economy of operation, overruled its executive officer and ruined the discipline of the plant. The damage to the commission, directly and indirectly, by loss of discipline from that day to this, by the loss of capable employes and the expense of educating others, has offset many times the saving which was expected to be made. The trimmers struck, as I have said, and thereby put themselves in the wrong. They had no right to conspire to put the metropolitan city of Michigan in darkness. They forgot they were public servants when they planned such a stroke. That also is a minor detail. The major fact was that the commission assumed control of details which, even had it been competent to judge, it could not personally oversee, and deliberately permitted employes to feel that they had a grievance.

The engineer did his best. He won the strike for the commission, feeling that his duty to the city overrode his sympathy for the men; but thereafter he avoided responsibility, knowing that he could not depend on the support of his directors, and the clamor raised by the aggrieved employés had its unavoidable result. The appointing power, the mayor of the city, tried to remedy the harm done by nominating a commissioner who undertook to specially represent these employés, and who entered on his duties with a prejudice against his associates. This appointment was followed by another; this second nominee frankly declaring himself the special representative of organized labor. Partisans both of them, these commissioners; well meaning, no doubt, but limited in their action by the circumstances of their appointment, carrying to their duties not a receptive mind, but a preconceived hostility to the past management. At meetings of the board charges and countercharges, criticism and squabbles took the place of frank discussion and of willing submission to the decision of the majority. Talebearing by employés was encouraged, different members assuming the protection of different employés or cliques of employés. Matters of detail took up the time of the board, and business was impossible. The plant kept on going from sheer inertia, but the engineer very early concluded that he should end his connection with the institution. He had been wiser for himself, I think, had he come to this conclusion a year sooner than he did; but he, like almost all engineers, was faithful to his salt and tried to do the best for his masters, the public, under adverse circumstances. He economized to a fault; he left his machinery in perfect condition and a surplus of over $50,000 in the treasury. The older commissioners finally gave an opportunity for the restoration of harmony by resigning almost in a body, and new nominees of the mayor, on whom, by these resignations, has devolved the appointment of every present member of the commission, accepted appointment to the vacancies.

Had the commission then reverted to the original system of operation, all might have gone well. Seeing that all personal difficulties had been eliminated, they could have resumed their proper legislative duties, placing the executive responsibility in the hands of one competent engineer. If a local man were not available, they could have sought for such an engineer beyond the city, as did the first commission. Unfortunately, the factional spirit still survived. Employés and ex-employés who had given aid and comfort to the commissioners now dominating during the time when they were a minority apparently had to be taken care of, and these commissioners found themselves the representatives of a faction of the most impracticable kind. A general superintendent was chosen, but he is superintendent in name only. When appointed he did not know the elementary principles of electrical generation and distribution, and he thereby became dependent on one of the reappointed ex-employés, who was nominated as his assistant. In the public reports and specifications of the commission there is nothing to indicate that during the past year the general superintendent has learned any more about the electrical business than he knew when he started. I regret to say also that these reports and specifications indicate that not merely the general superintendent lacks essential knowledge, but that the assistant is far from having sufficient engineering ability to make good the deficiencies of his chief. It seems ridiculous that a plant which has sent a dozen smart electrical engineers to profitable employment elsewhere should not be able to find one able man to take intelligent charge of its own affairs. A private plant, offering the same salary, would have found such a man very promptly.

Of course (as shown by my text) the belief has gone abroad that partisan politics have dominated the selection of employés by the new commission. There is too much evidence in favor of this belief to allow one to contradict it lightly. There is a good working majority vote in the commission, and under those conditions it behooves the majority to be careful of its appointments if it desires that its motives shall not be impugned. To appoint as a general superintendent a person who has been a practical politician since the memory of man runneth not to the contrary is a proceeding subject to criticism under the best of circumstances. When the person so appointed knows absolutely nothing about the business he is running, when he and his assistant jointly send around to their subordinates a subscription paper inviting the donation of campaign funds for the party having the majority vote on the Public Lighting Commission; when other appointees to office are also notably party workers, and either without electrical experience or with an experience which is a record of failures, it seems to be a prejudged case that politics control the department.

The financial results do not clear the record. The past president started in with a remarkable programme of proposed economies. He announced that expenses could be reduced $20,000 per annum. During the year of his control the expenses apparently have been increased to the tune of $10,000 per annum, and for the first time in its history the commission comes before the Board of Estimators reporting that it will apparently have a deficit at the end of the current fiscal year. That result indicates that there was something wrong with the programme, and increases rather than decreases the evidence against the present system.

My conclusion is that a public works department can be operated efficiently and economically on the same lines as is the service of a private corporation; the commissioners assuming the duties of the directorate of such a corporation and the general superintendent, who must be a thoroughly competent engineer, performing all the executive duties. I can admit no exception to this rule. I am aware that in some organizations the peculiar knowledge of individual directors makes their advice exceedingly valuable in the executive department. This was the case in the first Public Lighting Commission of the city of Detroit. Of that commission, there was not one man who had not a general knowledge of the apparatus and methods involved in the electric lighting business; three of these had served as directors of electric lighting enterprises. The factory of one was a pioneer in the use of electric power distribution, and the commissioner who knew the least of electrical affairs was surprisingly familiar with the routine and costs of a model street railway plant in which he had an interest. Two of the members had technical knowledge and ability which brought them, in the course of their business, a large recompense, and which they gave freely to the service of the city of Detroit. One of these men had been a pioneer in telephone, electric light and electric railway developments, and he is now an officer and director of one of the largest telephone companies in the Middle West. The other, whom I may name, seeing that he is dead, Mr. George Howard Lothrop, was reputed the best authority on electrical patents west of the city of New York. The advice of these men was constantly sought by me as the executive officer of the Public Lighting Commission, and it was always freely given and always valuable. I have indicated sufficiently the peculiar fitness of the first Lighting Commissioners of this city to take charge of detail and to perform the executive duties of their department, and yet it was these commissioners, who knew exactly what they were doing and who were, without exception, better fitted for their public work than any of their successors have ever been who positively declined to depart from their legislative functions and who insisted upon the assumption by their general superintendent and engineer of the full responsibility and the full authority which his executive duties required. It has remained to men of less knowledge to initiate the contrary policy and to fail in it.

What has been done can be done. Let the Public Lighting Commission of the city of Detroit re-enact the rules of the first commission. Let it place the execution of these rules in the hands of a general superintendent who shall be—who must be—a thoroughly competent electrical and mechanical engineer. Let the commission confine its members to their legislative functions, and loyally support its superintendent in his executive duties. Then there will be again a Public Lighting Department free from politics, free from partisans, economical in operation and a model to be followed not only by other municipalities, but by private corporations. Go outside of Detroit, if necessary to find the right superintendent. If he is an honest, capable engineer—and an engineer, to remain in his profession, must be honest and capable—his freedom from local acquaintance and entanglements will tend to his success.

Insecticide for Fowl.—Wendelen recommends, as a highly effective remedy, a mixture of lime and sulphur, to which is added, every week, air-slaked lime mixed with finely sifted coal ashes. The chickens like to bathe in this mixture and get rid of the vermin.—Pharmaceutische Post.

DIRECT-DRIVEN CONTINUOUS-CURRENT GENERATORS FOR LIGHTING AND POWER.

IN modern central stations, economy of space is often of vital importance, and the use of belt-driven machinery is on this account often impracticable.

The multipolar type of construction for direct-current generators permits the economical manufacture of slow-speed machines adapted to direct connection with engines.

For many installations direct-driven generators have important advantages which are lacking in belt-driven machines. They require less floor space per kilowatt output, which means a saving in investment in real estate and building. They operate at a higher efficiency, with a consequent saving in coal due to the elimination of losses in belting and counter-shafting. With their use the wear and tear and depreciation of belts are avoided. They admit of the operation of isolated plants in residences and other places where the noise due to belt-driven machinery would not be tolerated.

In the design of its direct-driven continuous current form L generators the General Electric Company has spared neither time nor money to bring them to the highest degree of perfection, and the results are most gratifying. The new machines embody all the excellent features of the old type, together with numerous improvements. They have ironclad armatures, although smooth-core generators of types previously standard will be built to order if, for any reason, they are preferred.

For isolated stations, 125-volt generators are, as a rule, preferable; but for large central station units the voltage is usually from 250 to 300, although these generators can be furnished for 125 volts.

The frame is cast from specially selected soft iron of the highest magnetic permeability, while the pole pieces are composed of soft cast steel also of great permeability.

The armature is so constructed as to permit a thorough circulation of air through the core, windings and commutator, thus insuring perfect ventilation and consequent cool running. The armature is drum wound, and consists of a laminated core built up of sheets of soft steel, thereby reducing the heating to a minimum, and increasing the efficiency of the machine. The laminations are punched with perfect uniformity by dies, and when assembled form a rigid core with smooth slots in which the conductors are embedded.

An important feature of the armature construction is the practical elimination of the danger of short circuits and similar troubles. The armature windings, which are separately insulated, consist of straight copper bars of the highest conductivity, requiring but two joints for each convolution, and any repairs can be made with the greatest facility. The armature core affords the winding thorough protection from mechanical injury during assembly and transportation. The end connections are supported by flanges on the armature, and the construction of the core renders the use of binding wires over the laminations unnecessary. The armature is connected with the commutator by copper leads carefully insulated.

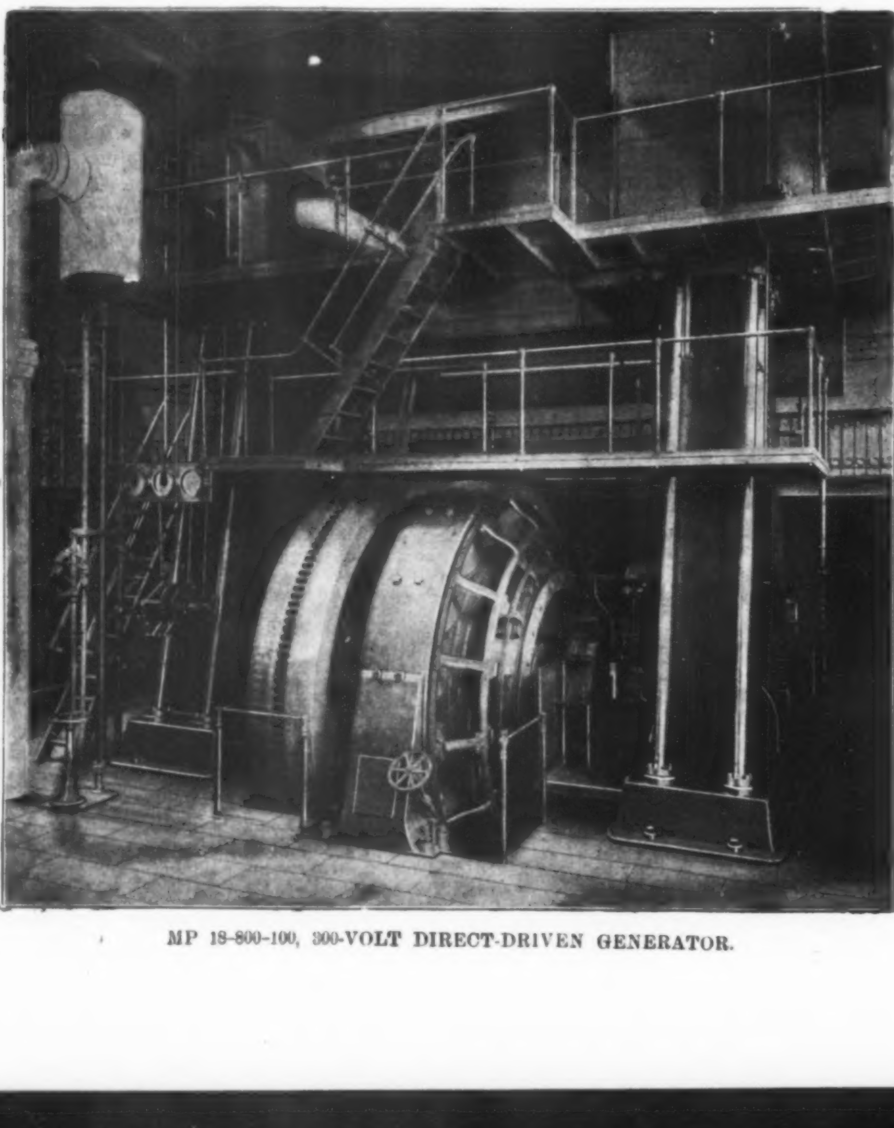
The commutator shell, which is of cast iron, is pressed on the armature spider, and is independent of the shaft. The commutator segments are of hard-drawn copper, insuring long life and uniformity of wear.

A feature worthy of special attention is the brush-holder yoke, which is fastened to the magnet frame in such a manner as to permit the easy movement of the brush-holder studs. The brushes are readily accessible for either adjustment or removal, and the construction of the holders is such that a brush can be removed for inspection without changing either the adjustment or the tension.

The following is the General Electric Company's standard basis of rating for form L generators:

The temperature of no part of the armature or field coils, as measured by the thermometer, after a run of 24 hours at rated amperes and rated volts, with normal conditions of ventilation, will rise more than 35 deg. C. or the commutator more than 40 deg. C. above that of the air surrounding the machine, provided the temperature of the air does not exceed 25 deg. C. With the load then increased to 50 per cent above the rated amperes, and at rated volts (50 per cent overload) for two hours, the accumulated temperature of no part of the generator will be more than 55 deg. C. above that of the surrounding air. The General Electric Company considers it preferable to adhere to the method of taking temperatures with thermometer in the case of the armature core, commutator and armature windings, as well as the bearings, owing to the difficulty of accurately determining the temperature rise of these parts by the increase of resistance method. In the case of the field coils, this difficulty being inconsiderable, the company will, when requested, guarantee that the temperature of the field coils, as measured by the increase of resistance method, will not be greater than 45 deg. C. above the surrounding atmosphere after a 24 hours' run at full load. In the event of the temperature of the surrounding air differing from 25 deg. C., the above rise in temperature is to be corrected ½ per cent for each degree C. that the temperature of the surrounding air differs from 25 deg. C.

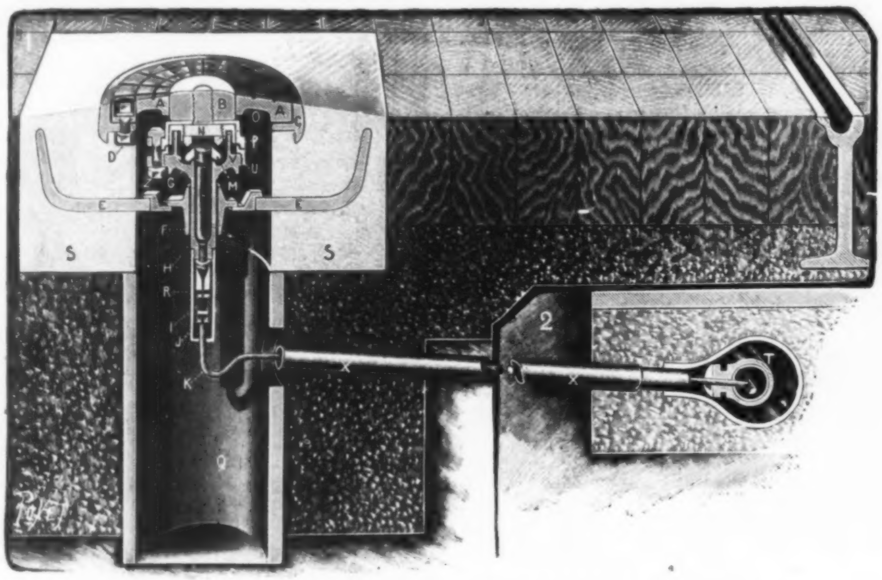
The generator will carry an overload in current of 50 per cent at rated volts for two hours without movement of brushes, and 100 per cent overload at rated volts momentarily, without injurious sparking.



MP 18-800-100, 300-VOLT DIRECT-DRIVEN GENERATOR.

SUPERFICIAL CONTACT ELECTRIC RAILWAYS.

IN 1899 an installation of electric tramways with superficial contacts of the Diatto system was made at Tours. We gave a description thereof at that epoch,* and, at the end of our article stated that we should soon see the system in operation at Paris. Since then two companies have been formed to exploit it—the Compagnie de l'Est Parisien and the Compagnie de l'Ouest Parisien.



SECTION OF THE DIATTO SUPERFICIAL CONTACT SYSTEM.

1. Installation of a contact box. 2. Branch from the main cable.

The system is very simple. It consists in laying underground, on a line with the track, a cable that leads the electric energy from the works, and in afterward branching it in order to furnish, by means of a superficial contact, such energy to the car at the moment that it passes over the said contact or "plot." By this name is designated a metal box set into the roadbed, and in which is installed a rod forming an interrupter. These boxes are so spaced as to permit of establishing a continuous relation between the current and the motor of the car. Under each car is suspended a magnetized bar which passes over the contact boxes, attracts a rod that plunges into mercury and thus establishes a circuit between the cable and the car.

The accompanying figure gives a section of the apparatus. The block, *S*, is of asphalt. In the center of it is reserved a space for the reception of the contact box. Beneath is an earthenware cylinder, *Q*, that establishes a direct communication with the ground.

The edges of the contact box are flush with the surface of the roadbed, and the center projects 0.8 of an inch above the pavement. The boxes and the track are placed upon a bed of concrete.

At the upper part of the space in the block, *S*, there is a movable cover, *A*, of antimagnetic metal, and in the center there is a core, *B*, of soft iron. A piece of cast iron with bent arms, *E E*, at the sides is set into the mass of the box and supports a cast iron sleeve, *F*.

The soft iron core, *B*, carries a screw plug, *N*, which is provided with a block of graphite, *O*, having in the interior a cone-shaped opening into which accurately fits the graphite head of the rod forming an interrupter. The screw plug, *N*, keeps fixed against the piece, *A*, a brass bell, *P*, which is secured by means of three bolts, *Z*, to an ambroine cup, *V*. This latter terminates in a tube, *G*, at the bottom of which there is a copper plug, *H*. This tube is prolonged by a tube, *R*, that forms a funnel and terminates in a metal cup. The tube, *R*, is hermetically closed beneath and leaves merely a passage for the entrance of the electric cable. The copper plug, *H*, carries a copper wire, *I*, which dips into a little mercury contained in the cup, *J*. The electric cable is fixed at the lower part. The tube, *G*, is filled with mercury into which plunges the iron rod, *L*. This tube, *G*, passes through the sleeve, *F*, of the cross piece supported by the arms, *E E*. The rod, *L*, is provided with a graphite head, *M*, in the form of a truncated cone having a flange that permits it to rest upon a prolongation of the lower tube in the interior of the cup, *V*.

The weight of the interrupter is balanced by the thrust of the liquid; a feeble attraction suffices to raise it. Finally, the feed wire for supplying a "plot" is run from the main cable through an outlet box, *T*. The cable afterward passes through a tube, *X*, and at *K* enters the lower part of the tube containing the mercury.

Such are the principal arrangements of a system which is relatively simple, but which, from a practical viewpoint, necessitates a series of precautions. During the construction of the tracks in Paris a number of modifications were made, and of these we propose to speak. We have already seen that under

* SCIENTIFIC AMERICAN SUPPLEMENT No. 1247, page 19991.

the box containing the mechanism there is arranged an earthenware cylinder to assure the drainage and prevent water from collecting at a determinate point. Even if water should enter the box the tube forms an airtight bell and prevents the ascent of the liquid.

The magnetized bar is composed of three parts, between which are mounted horizontal electro-magnets arranged in such a manner as to communicate north polarity and south to the two lateral ones. Each electro-magnet has two windings, distinct and of the same direction. When in operation they are actuated by the main current which circulates in one of the windings. But at the moment at which the car is started the current necessary passes into the second winding, and is furnished by a small battery of accumulators giving 18 amperes and 16 volts placed in the car. The actuated electrodes attract the interrupter, which rises and, through the contact of the carbon, connects the electric current of the power house with the electric motors of the car.

In order to prevent too abrupt a breakage the back of the bar is raised. The result is that at the moment at which the contact of the bar with the contact boxes ceases the attractive action continues and still keeps the interrupter lifted for a few instants. The breakage spark therefore occurs at the exterior, between the bar of the car and the contact box, at the moment of the fall of the interrupter.

The proper operation of the system of superficial contacts requires that the communication of the current from the works with the "plots" shall exist only during the passage of the cars and shall be suppressed immediately afterward in order to prevent any accident that might happen with a tension that generally equals 500 volts.

A special preventive measure has been taken to avoid this danger. The copper wire, *I*, that plunges into the metal cup, *J*, and is connected with the cable of the works is mounted in tension with a fusible lead wire. On another hand, a drag formed of several wires attached to the rear of a car rubs upon a contact box. If the current has, for some reason or other, remained upon the latter, there results a short circuit through the metallic mass of the car, and the fusible wire melts and interrupts the line.

Let us add that the "plots" have a certain insulation with respect to the earth, that their operation has to be carefully watched, and that the system must cause neither strong sparks nor noise at the moment of the breakage of the circuit.

It seemed, then, as if the Diatto system possessed all the qualities to allow it to operate under the best of conditions. And such, indeed, was the case at Tours, according to the data that have been furnished. But at Paris there soon occurred a series of accidents of all sorts that filled the public with fright. From June 15, 1900, to February 20, 1901, there were 120 of such accidents, of which 58 happened during the month of January. Among all these the most important was the shocking of horses. These successive accidents greatly excited the public. Discussions took place upon the subject at the Municipal Council, and, by resolution, the prefect of police was ordered to prescribe certain arrangements to assure safety. The question was finally submitted to the Minister of Public Works, who consulted the committee on the technical exploitation of railways. This latter, after an examination of the matter, ascertained what accidents and dangers might result from the exploitation of the Diatto electric tramway in Paris, and indicated the causes thereof.

It is very certain that the majority of the accidents have the same origin, viz., the permanent electrization of the plots. Now, horses are very sensitive to such electrization. It has been stated that it is impossible, without inconvenience, to put more than 5 volts between their hoofs, touching the rails on the one hand and the plots of the contact system on the other. In order to avoid so feeble differences of potential it would require an absolute insulation difficult to obtain. This first consideration shows us that the accidents that happen to horses are not due to an electric current of dangerous tension, but to the fact that the animals are of exceptional sensitiveness.

In addition to the elementary measure of precaution consisting in avoiding a passage over the rails and plots at the same time it was necessary to give other instructions with a view to preventing any danger.

The committee reduced all the accidents observed to five principal causes: (1) Mechanical deterioration of the plots; (2) action of the drag; (3) imperfect insulation of the plots; (4) deposit of soot inside of the cups; (5) imperfect insulation of the cables. It was easy to remedy the deterioration of the plots by selecting a more perfect material. The drags placed in the rear of the car and designed to melt the lead fuses of the derivation as a measure of security, caused great inconvenience. In fact, at the moment at which the drag attracted the interrupter it established accidental short circuits between the plot and the rails, and it was possible for these still to persist after the interrupter fell. At the same time, it was possible for an arc to form between the two carbons in the interior of the cup. In consequence of the great resistance that the arc had to overcome in order to persist, the intensity of the current was feeble and could not cause the fusible lead to melt. The safety drag was therefore rather prejudicial and was done away with.

In order to give greater stability to the plots the latter had been directly secured to metal ties connecting the rails. Such an arrangement could but weaken the insulation of the plots and involved serious consequences at the time of salting the track after falls of snow. The companies employing the Diatto system were therefore requested to leave a sufficient space between the ties and the plots to assure the latter a better insulation, and an agreement was made that the track should not be salted after a fall of snow.

Experience has demonstrated also that when the operation of the plot is not very regular it forms extra current arcs which, in consequence of the combustion of the materials composing the box, give rise to soot. This latter establishes a communication and the current remains upon the plot. It is therefore expedient to take measures to suppress the production of this substance.

Finally, the cables presented an imperfect insulation, and this the companies were requested to improve, as well as to drain the plots more perfectly.

Instructions to effect these modifications before the first of October, 1901, have been given by the prefect of police to the companies that are exploiting the Diatto system in Paris.—For the above particulars and the engraving we are indebted to La Nature.

A TELESCOPIC GUN-SIGHT.

THE modern sportsman has not been slow in adopting the modern small-caliber firearms, so remarkable for their extraordinary range, flat trajectory and astonishing velocity. Unfortunately, however, the human eye has not developed with the firearm, and it has been one of the greatest objections to the use of these long-range weapons that it has been difficult to obtain accuracy at great distances, by reason of the deficiencies of the eye. In order, in a measure at least, to assist the eye in computing ranges, a telescopic sight has recently been invented in Germany for the purpose of enabling the sportsman to manipulate his weapon with an accuracy which has never been before attained. According to Moderne Kunst, the instrument consists of a telescope mounted on the barrel in the manner shown.

THE TELESCOPIC SIGHT.

In the construction of the sight a device, *E*, is used to ascertain the elevation. A colored glass, *S*, is provided for the purpose of diminishing the intense brightness of the sunlight, and likewise an eye-shade, *G*, mounted in front of the eye-piece, *g*, in order to cut off light coming from the sides, to which light many eyes are extremely sensitive. Our upper illustration shows that it is possible so to dispose the finder that the sights with which all guns are usually provided, need not be dispensed with.

Of the many merits claimed for this instrument, one of prime importance is, perhaps, the simplification of aiming; for the eye has but to glance through the tube. It is not necessary to bring the parts of two sights into a certain relative position. Furthermore, the adjustment of the sights for different ranges is now no longer necessary, the telescopic sight being good for all ranges. By reason of the power of this telescopic sight, the marksman can draw a bead on his game at twilight or dawn with great accuracy, at a time when the ordinary sights would fail him.

DISAPPEARING CARRIAGE FOR A 1.4-INCH GUN.

THE automatic gun invented by Engineer Maxim fifteen years ago, and adopted at present in the majority of navies is well known. The principle of the gun resides in the use of the recoil, for loading the weapon for the following shot, so that the firing of one shot brings about that of the subsequent one, and so on, with a rapidity of 300 shots a minute. It is, in a manner, a true engine in which the cartridge performs the office of steam, the breech block that of a piston, and the trigger that of a distributing mechanism. It is the same principle that was applied by Mr. Maxim to the mitrailleuse that bears his name, and that has been adopted by a large number of powers. The mechanism of the Maxim mitrailleuse differs from that of the Maxim gun only in dimensions, the former being of the caliber of a musket, and the latter of a caliber of 1.4 inches. The automatic gun may be employed upon a vessel upon two kinds of carriages. The first of these consists of a sort of standard that is generally installed upon the bridges or in the tops. The second system, not so generally known, is called a disappearing carriage. This has the advantage of being less cumbersome than the other and is well adapted for use in tops, where there is but little space at one's disposal. Moreover, it can be easily moved all along the bulwarks by means of a rack placed upon the rail of the latter and along which, by means of a winch, there may be moved a pinion formed integrally with the gun and its carriage. In this way the piece may be brought to the most favorable position along the bulwarks. There is of course a system of clamping for holding the pivot when the gun is not in service and another for rendering the carriage immovable at the time of firing.

Of the two figures of this carriage that we give here, one represents it in the firing position with its shield, etc., in place, and the other in the disappearing position, its habitual state when the piece is at rest.

In order to bring the entire system from the firing to the disappearing position, the shield is turned down, and the whole is then turned a quarter of a revolution to the right, so that the gun may be arranged parallel with the bulwarks. Finally, it is lowered by means of the double winch shown in the figure. This winch, through the intermedium of a worm gearing, revolves the toothed pinions that mesh with the teeth of the horizontal racks. This maneuver turns down the posterior leg of the tripod, the two front ones of which are capable of revolving freely around their joint-bolts. The whole is brought from the disappearing to the firing position by inverse means, and the gun is fixed in the latter position by inserting a key in an aperture in the rack frame. Nevertheless, even were the gunner to forget to put this key in place, the firing might be done without any grave inconvenience resulting. In fact, in the lower horizontal cylinder, there exists a powerful spiral spring that tends to sustain the gun. At the time of lowering the latter, this spring is compressed, and, when the piece is raised, aids in the righting of it and suffices to hold it in place.

The disappearing carriage permits of an amplitude of firing extending from a positive angle of 16 degrees to a negative one of 25, say a total of 41 degrees. This preponderance on the negative side is established by reason of the position in the tops that the piece has to occupy and of the firing to a short distance that it has to effect. The shield, which weighs 94.5 pounds, consists of a plate of steel 2.5 inches in thickness, which just serves to protect the gunners from pieces of the same caliber. The 1.8 inch gun, in fact, traverses 3.48 inches of the same metal.

The weight of the disappearing carriage is 1,725 pounds, and this, along with that of the gun, makes a total of 2,120.

The English house of Vickers, Sons & Maxim, which makes a specialty of this material, has constructed also a carriage and land forecarriage for this same gun; the weight to be hauled is 2,680 pounds, inclusive

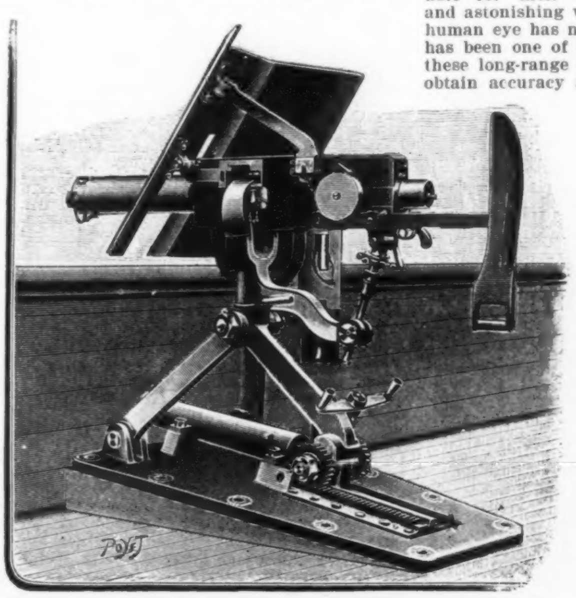


FIG. 1.—FIRING POSITION.

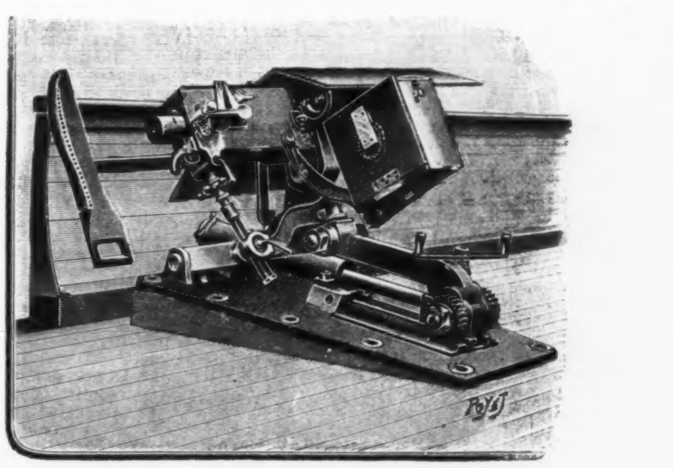


FIG. 2.—DISAPPEARING POSITION.

of ammunition for 300 shots. Four horses might suffice for the hauling. Unfortunately, it is not customary for vessels to carry horses to be used at a pinch, as it is too difficult to disembark and re-embark them. But even granting that such a difficulty could be removed by particular installations, the presence of horses on board would give rise to too great incumberment, and it would often prove difficult to give the animals proper care. It would certainly be preferable to employ a small locomotive.

The following are a few ballistic data regarding the Maxim automatic gun: The caliber is 1.4 inches and the length of bore 44 inches. The weight of the charge of powder is 525 grains, giving the 14-ounce projectile a velocity of 1,800 feet. The penetration of the projectile at extreme range is 1.9 inches in iron and 1.48 in steel. For the above particulars and the engravings, we are indebted to La Nature.

ANNUAL REPORT OF THE SECRETARY OF AGRICULTURE, 1901.

THE Fifth Annual Report of the Secretary of Agriculture, Hon. James Wilson, is considerably longer than in former years, reflecting thereby the great growth and development which has attended this Department during his administration.

WEATHER BUREAU.

He announces an important extension of the forecast field of the Weather Bureau, which now includes reports from certain points in the British Isles and on the Continent of Europe, from the Azores, Nassau, Bermuda and Turks' Island. The Atlantic forecasts based upon these reports now form part of the regular night forecasts issued in Washington. Three new forecast districts have been established—in Boston, New Orleans and Denmark. An extension of the forecast to farmers through the Rural Free Delivery is contemplated. Substantial improvements are reported in the Department's system of wireless telegraphy, of which the Secretary states in conclusion:

"While there is much experimental work yet to be done before the present system is reliable for intership communication, or before any two systems can work within the same field without each rendering the other useless, such progress has been made by the government experimenters that, with no interference by private systems, stations can be successfully operated over at least 150 miles of coast line, and they are now in operation on the North Carolina and Virginia coasts, and soon will be instituted between the Farallone Islands and the mainland and Tatoosh Island and the mainland, on the Pacific Coast."

ANIMAL INDUSTRY.

A large portion of the report covers the subject of animal industry. The grand total of animal products exported during the year exceeded $250,000,000 in value. This vast foreign market is only preserved to our producers by the indefatigable efforts of the Department and the rigid inspection exercised through the Bureau of Animal Industry. This Bureau inspected for export 375,000 cattle, 228,000 sheep and 48,000 horses and mules, and nearly 1,000 vessels carrying live stock. Imported animals were also inspected to the number of 342,000, and, where necessary, quarantined. The Secretary suggests that with the enormous interests our stock raisers have at stake, and inspection or quarantine affording, after all, a relative, not an absolute guarantee of protection, it might be well for this country to follow the example of Great Britain and exclude livestock from other countries entirely. The meat-inspection service involved the inspection at time of slaughter of nearly 37,000,000 animals. Of the more than 5,000,000 cattle inspected, the condemned carcasses were about one-fourth of 1 per cent; and of 24,000,000 hogs, one-third of 1 per cent. In the control of indigenous diseases, 1,500,000 inspections were made and over 45,000 cars disinfected in the Texas fever service alone. In the repression of scabies in sheep nearly 8,000,000 animals were inspected and over 1,000,000 dipped under the supervision of the Department inspectors. In combating the disease known as "black leg" the Bureau distributed over 1,500,000 doses of vaccine, the result being to reduce losses in affected herds to less than 1 per cent, where formerly it was in most cases about 10 per cent. To aid in detecting tuberculosis in cattle and glanders in horses, over 44,000 doses of tuberculin and 7,000 doses of mallein have been supplied. The Secretary points out the serious evil resulting from a system of State inspection, which, if it became general, would effectually prevent the marketing of live stock in some sections, and would destroy much of the usefulness of the Federal inspection. He regards the present conditions as so menacing to the interests of the cattle industry in the West and Southwest, that he has requested the Attorney-General to co-operate in bringing the matter before the Supreme Court for decision as to the constitutionality of these State laws. This request has been favorably received and the assistance of the Department of Justice promised.

PLANT INDUSTRY.

The organization of the Bureau of Plant Industry is reported. It has brought together in one group investigations in plant physiology and pathology, botany, grasses and forage plants, pomology, and the experimental gardens and grounds, including the experimental farm at Arlington, and the introduction of foreign seeds and plants.

Plant Physiology and Pathology.—Investigations in plant physiology and pathology have been lately devoted to the study of cotton diseases, diseases of orchard fruits, and of forest trees and construction timber. An interesting discovery to cotton-growers is reported of a cowpea resistant to the fungus that destroys the cotton roots. The cowpea being used in rotation with cotton, the securing a resistant cowpea will be of the greatest possible value to cotton-growers. Remarkable success is reported in experiments in plant-breeding to secure samples of cotton resistant to wilt and other diseases. Numerous valuable hybrids have also been developed. One from an American upland cotton and an Egyptian variety promises to be greatly superior to either parent. The Department has been for several years trying to secure by breeding a race of oranges resistant to frost. A cross of hardy Japanese with the Florida sweet orange has resulted in the hardiest evergreen orange known, and there is promise of ultimately securing a fruit both hardy and of good quality. Considerable success has also been attained in breeding raisin grapes resistant to the disease known as "coulure."

Botanical Investigations.—In botanical investigations important work has been done on seeds, improvement of crops and methods of crop production in our tropical possessions, and prevention of losses to cattle in the West from eating poisonous plants. The low germination of commercial samples of Kentucky bluegrass seed was investigated. It was found that there is a stage in harvesting this seed when heating takes place in the tops of the grass, piled in windrows, which tends to destroy the germination of the seed. This can be avoided by methods of handling the grass, but the Department is experimenting with machinery which will dry the moist seed without permitting it to heat. Comparative experiments regarding the relative value of American and European clover seed give results strongly in favor of the former, at least under conditions prevalent in this country. A remedy has been found which, when promptly administered, is effectual in the treatment of animals poisoned from larkspur and poison camas. The agricultural conditions of our new possessions are being thoroughly studied, and special attention is being given to the production in these possessions of tropical crops, for which the United States pays out millions of dollars annually. Raising coffee in Porto Rico has been the subject of special study. Our annual importations of this valuable crop now amount to $70,000,000. The Secretary asserts that much loss has resulted to the cattle industry in the West in recent years, owing to the injudicious management of ranges. The Department's experiments show that much could be done, under proper control, to restore the ranges to their original condition, and he recommends action by Congress, giving the President authority to secure for the experimental needs of his Department such tracts of public range lands as may be necessary.

Pomological Investigations.—The pomological investigations have been especially directed to the extension of the fruit markets abroad and to the encouragement of the domestic production of fruits hitherto largely imported. Prune growing has been made the subject of special study; also the growing of European grapes in the South. Attention is called to the rapid increase in our exports of apples since the magnificent showing of this fruit made by this Department at the Paris Exposition.

Arlington Farm—Tea Experiments.—Progress is reported in preparing the Arlington farm to serve in conducting experiments, as an adjunct to the Department. The Secretary cordially commends the experimental work now carried on at Summerville, S. C., under the direct supervision of Dr. C. U. Shepherd. About 4,500 pounds of high-grade tea, which found a ready market, were produced here during the year.

Introduction of Valuable Seeds and Plants.—Great activity has characterized the introduction of valuable seeds and plants from abroad, with most satisfactory results. The development of the rice industry in Louisiana and Texas since the introduction by the Department of the Japanese rice, during the past three years, has been remarkable. At the same time our imports of this product have decreased from 154,000,000 to 73,000,000 pounds. The United States imports yearly nearly $800,000 worth of macaroni. Macaroni wheats have been introduced in the past two years very successfully into the Dakotas and also into Kansas and Nebraska. Fully 90 per cent of the date palms introduced in recent years from Africa are now growing vigorously in Arizona and southern California. This year a collection of the choicest varieties in Egypt have been obtained. Progress is reported in the introduction of Egyptian cotton. The imports of this product now amount to about $8,000,000 yearly.

Congressional Seed Distribution.—In regard to the Congressional seed distribution, the Secretary states that he has endeavored to meet the wishes of Congress in every way possible and to secure seeds of as high a character as can be obtained under the conditions under which the work is done. It has been arranged to send out cotton seed, tobacco seed, sorghum seed, and sugar-beet seed, and grasses and forage plants, under the direct auspices of the Department, and not through the contractor.

BUREAU OF SOILS.

The Division of Soils has recently been made a Bureau and has received increased financial resources, which enable it to extend its scientific investigations, as well as its practical operations.

Soil Survey.—An extensive review of the work of soil survey shows that the areas surveyed and mapped during the year exceeded 3,500,000 acres, making a total of nearly 6,000,000 acres surveyed during the past two years. The field work, including preparation of reports, transportation and supplies, has cost an average of $3.26 per square mile, or about 51 cents per hundred acres. A part of the expense has been paid by State organizations, and effective cooperation has been had with the stations. The demands for soil survey in various parts of the country continue to be received in excess of the ability of the Bureau to comply. The Secretary enumerates sundry important results in the work of the survey, but dwells especially upon what has been achieved in connection with tobacco. Especially successful have been the experiments made by the Bureau in the growing of a fine type of Sumatra leaf on certain soils in the Connecticut Valley. During the past year nearly 43 acres have been grown under the direct control of the Department experts. An interesting feature of the experiment is that the bulk of the cost, estimated at $20,000, has been invested by the farmers themselves, and it is gratifying to record that their enterprise has been rewarded far beyond their expectations. The recommendations of the Department have also been followed in the methods of curing tobacco in Pennsylvania, with the result of effecting a saving from the ravages of the black rot, exceeding one-half million dollars. Urgent demands for assistance in the tobacco industry have reached the Department from New York, Wisconsin, Texas and Florida. Referring to the reclamation of alkali lands, to which attention has frequently been called in the reports of the soil survey, the Secretary says that he is more and more convinced that to carry the lesson home to the individual it will be necessary for the Department itself to undertake a practical demonstration of the efficiency of drainage. The necessity of a special study of climatology in connection with the soil work is pointed out. "The time has come," says the Secretary, "when the work should be taken up on a scale commensurate with the extension of at least two or three crop interests. It is certain that the immediate benefit to the farmers will amply repay expenditure."

WORK OF THE BUREAU OF CHEMISTRY.

In this Bureau investigations into the composition, nutritive value and adulteration of food products have been continued. This work during the year was devoted particularly to the study of preserved meats, the composition and nutritive value of the preserved article being compared with the original, and the preservatives, if any were employed, determined. Food products imported into this country, and suspected of adulteration or of containing injurious constituents, have also been examined. The Secretary is authorized to inspect, through the Bureau of Chemistry, American food products intended for export. Unfortunately, Congress has not provided appropriations adequate to the proper execution of this law. The Secretary adds that it is important that our food products going abroad be pure and wholesome, and that we should protect our exporters against discrimination in foreign countries.

In connection with the Bureau of Forestry, the chemist is taking up the work of forest chemistry, and is studying forest trees in their relation to the soil and the products they yield. Among the chemical industries immediately dependent on forest productions are the tanning industry, manufacture of wood pulp, production of wood spirit, charcoal and other products. The sugar laboratory of the Bureau continues to study all the chemical problems relating to the production of sugar-producing plants and the manufacture of sugar. The chief part of this work is devoted to the study of sugar beets. The work that the Bureau of Chemistry is doing for other departments of the government is considerable and constantly increasing. By agreement with the Secretary of the Treasury, the chief of the Bureau has been designated as supervisor of sugar tests in the laboratories of the appraisers in the ports of New York, Philadelphia and Boston. The other departments to which the aid of the Bureau of Chemistry has been extended are the War Department, the Post-Office Department, the State Department and the Department of the Interior.

In cooperation with the Office of Public Road Inquiries, a laboratory for the study of road materials has been organized in the Bureau of Chemistry. The prime object of this laboratory is to aid road-builders in selecting the best available materials in their localities.

WORK OF THE BUREAU OF FORESTRY.

Another of the newly organized bureaus is that of Forestry. The Secretary reports that this Bureau is cooperating with the Federal Government, with several States and many private owners in handling their forest lands. Altogether, assistance has been asked for a total area of 52,000,000 acres, of which 4,000,000 are held by private owners. The work of forest management is reviewed in some detail. During the year nearly 800,000 acres under private owners were examined by representatives of the Bureau, and four detailed working plans, covering 226,000 acres, were prepared. The working plan for the Black Hills forest reserve was completed and working plans were undertaken for the Prescott and Big Horn and the Priest River reserves.

Forest investigations include the study of commercial trees and economic tree-planting, of forest fires, grazing, lumbering, forest productions, and other important lines. The region containing the proposed Appalachian forest reserve was examined in cooperation with the United States Geological Survey, and nearly 10,000,000 acres were mapped, lands classified and the forests carefully studied. The Secretary regards the creation of the proposed forest reserve as urgent in order to protect the headwaters of important streams, to maintain the already greatly impaired supply of timber and to provide a national recreation ground. Upon the request of the Secretary of the Interior, the effects of grazing and forest fires were investigated on twelve of the forest reserves.

In the study of economic tree-planting in cooperation with farmers and others in making forest plantations, 46,145 acres were examined and plans were prepared for nearly 6,000 acres, while 148,000 applications for tree-planting plans were received.

THE OFFICE OF EXPERIMENT STATIONS.

The Secretary reports, as the result of a broad inquiry made through the Office of Experiment Stations, that by far the largest part of the work of the stations has direct relation to the important agricultural interests of the communities in which they are located.

The work of the stations is becoming better understood by the farmers, and a broader, deeper foundation of scientific inquiry is being laid each year. Cooperation between the Department and the stations continues to increase, and the value of these cooperative methods to the agricultural interests is very generally acknowledged. As a result of the practical confidence so attained, Congress and the State Legislatures have shown a disposition to be liberal with this Department and with the stations. The movement for the separation of the office of director of the station from that of president of the college has advanced, and at present there are but eleven States and Territories in which the college president exercises the functions of director of the station. At the same time, the amount of teaching required of station officers has been materially reduced.

The experiments of the station in Alaska, with headquarters at Sitka and subsidiary stations at Kenai, on Cook Inlet, and at Rampart, in the Yukon Valley, are regarded as distinctly encouraging. From all the evi-

dence received at the Department, it seems clear that agriculture may be sufficiently established in this Territory to serve as an important aid to the mining, lumbering and fishing industries. During the year a station has been established in Hawaii. Among the first work at this station was the planting of taro, with the special object of studying the diseases seriously affecting that crop. Probably 50 per cent of the working population in these islands depend on taro for their daily food, and, owing to these diseases and the attendant deterioration of the crop, the price of taro has increased 500 per cent in the last decade. Some other diseases of fruits and vegetables call for study, and poultry experiments have been inaugurated with a view to increasing the supply of poultry. It is reported that live chickens sell in Honolulu at $15 a dozen and eggs at 40 and 50 cents a dozen. Hogs bring from 10 to 17 cents a pound on the hoof, and experiments have been undertaken in the feeding of swine with various tubers and roots.

The station at Porto Rico has not yet been fully established, owing to the difficulty of securing suitable land for the purpose. In the meantime, such investigations will be undertaken as can be pursued on lands leased or loaned by persons ready to engage in cooperative work with the station director. Some preliminary investigations in coffee culture have already been arranged for.

The Secretary earnestly recommends that the annual appropriations for all these stations be increased to $15,000, the same as the National Government contributes at present to all of the other stations in the various States and Territories.

The Philippines.—He regards it as extremely desirable that agricultural investigations should be undertaken in the Philippine Islands under the War Department and in cooperation with the Department of Agriculture. In furtherance of this work, the Secretary recommends an additional appropriation of $15,000 for the ensuing fiscal year "to institute agricultural investigations in the Philippines and, if feasible, to locate and maintain an agricultural experiment station there."

Agricultural Education.—An increase in college-extension work in agriculture is noted and stress is laid on the movement for the establishment of secondary schools of agriculture and the introduction of the elements of agriculture into the rural schools, as hopeful signs of progress in agricultural education. The Secretary suggests that his Department, already giving aid to rural schools in various ways, should take a still more active part in encouraging this work. He recommends encouragement by distributing seeds and plants to establish school gardens, by furnishing schools with collections of specimens of insects, of plant diseases, and other illustrative material, and by supplying the teachers with such publications of the Department as may be useful to them.

Aid to Farmers' Institutes.—He reviews very fully the great development in the work of farmers' institutes. In 1899 over 2,000 farmers' institutes were held in this country, attended by over half a million farmers. These were held in forty-three States and Territories. The Secretary thinks that there is room for much useful work by his Department in aid of this and other movements for the education of our farmers in the improvement of our agriculture. He has therefore asked for a special appropriation of $5,000 to enable the Office of Experiment Stations to enlarge its work with a view to giving definite aid and encouragement to farmers' institutes in the different States.

Nutrition Studies.—The dietary studies and experiments in cooking, digestion and metabolism, have been conducted in various parts of the United States in cooperation with experiment stations, agricultural colleges and universities. The results of nutrition investigations already made should, the Secretary thinks, be practically and beneficially applied to the feeding of men wherever a considerable number of persons are to be fed on a systematic plan. He instances the hospitals for the insane in the State of New York, the annual cost of food for which is over $1,000,000, and states that of the $26,000,000 expended for 100,000 persons maintained in the public institutions in New York State alone, $6,000,000 is expended for food. He urges investigations to determine the best dietary for the use of our soldiers and civil officers in tropical regions, and states that a special appropriation of $5,000 has been asked for the study of the food supply and consumption of people living in the tropics.

(To be continued.)

TRANSPARENCY FOR CERTAIN RAYS OF THE SUN AS A SOLUTION TO THE PROBLEM OF THE GENESIS OF THE ELEMENTS.

In the issue of the Scientific American of January 26, 1901 (No. 4) you published a few remarks of mine in regard to the cause of transparency for heat and other rays, in which I stated that an apparent relation exists between the transparency for heat (infra-red) rays and the carbon contained in chemical compounds; between hydrogen and the light or visible rays, and also between oxygen and the chemical (ultra-violet) rays. Some additional facts in this connection may be of interest to your readers.

Three classes of rays reach us from the sun, namely, heat, light and chemical rays. Tyndall and other investigators have stated that all liquids and solids differ in regard to the kind of rays which can pass through them, and I have seen no plausible explanation for the same. In Tyndall's "Fragments of Science" he says that absorption of heat in liquids augments as the number of atoms in the molecule augments, bisulphide of carbon with only three atoms showing the least absorption, but also states that water and alcohol are exceptions to this rule. In regard to water he says:

"I would recommend to the particular attention of chemists the molecule of water, the deportment of this substance toward radiant heat being perfectly *anomalous* if the chemical formula at present ascribed to it be correct."

He also says that the reason alcohol with only nine atoms shows greater absorption than benzine with twelve atoms may be because the molecule of the former is rendered more complex by the introduction of a new element, oxygen.

In his "Glaciers of the Alps," however, he says that a layer of water one-twentieth of an inch in thickness suffices to stop and destroy all waves of radiant heat emanating from an obscure source, and that he finds all transparent compounds which contain hydrogen are peculiarly hostile to the longer undulations.

His attempts at explanation are, therefore, contradictory. The only reasonable explanation is that carbon is the cause of transparency for heat. He also says in "Fragments of Science": "I have myself succeeded in transmitting between 40 per cent and 50 per cent of the radiations from a hydrogen flame through a layer of carbon which intercepted the light of an intensely brilliant flame."

Some very interesting conclusions can be drawn as to the genesis of the elements from the foregoing.

Most scientists nowadays believe that the so-called elements are in reality compounds. Some hold that they are mostly built up of hydrogen, and others that oxygen is contained in many of the elements, while it is also generally believed that these hydrogen and oxygen atoms can be broken up into what are called corpuscles. Strange to say, however, the probability that carbon is contained in some of the elements has apparently received but little consideration, in spite of the fact of its low atomic weight and that it has been discovered in great quantities in this earth of ours, in the rocks and elsewhere. The non-metals phosphorus, sulphur and iodine, and all the halogens, possess the same property as carbon, of extraordinary transparency for the invisible heat rays, not only alone but when combined with other elements. Thus iodine dissolved in bisulphide of carbon is extremely transparent for these rays, but cuts off the other rays, and the particular fact to which I would call your attention is that iodine, phosphorus and sulphur are soluble in carbon compounds and insoluble or but slightly soluble in water. Surely this is not a mere coincidence! Surely not, when we consider that "like dissolves like"; that there is in most cases a relation to be seen between the chemical composition of the solvent and that of the solid it dissolves; ether and benzine, both highly carbonaceous liquids, freely dissolve fats and other substances which are rich in carbon. Furthermore, iodine, sulphur and phosphorus are, like carbon, poor conductors of heat. There can be no conduction of heat without absorption, and I will next call your attention to a lot of evidence to show that the metals that are the best conductors of heat are composed of hydrogen and oxygen, the same as water, or composed in great part of these two elements.

Water absorbs a small amount of light near the red end of the spectrum, so that the rays which pass through are slightly colored greenish blue; the absorption of light rays by the metals copper, silver and gold is also greatest at the red end of the spectrum, while the rays which penetrate their surfaces are much the same as those which penetrate water. These metals in thin films transmit light of a greenish color—copper in the fluid condition is of a sea-green color. The colors which greater thicknesses of these metals display are due to absorption, and are all of about the same general color, made up of rays from the red end of the spectrum. When a beam of light enters the eye after undergoing repeated reflection from gold to gold it is of a deep orange color, which is the true color of gold. The true color of copper by the same method is scarlet, of silver yellowish-bronze. This reddish color of absorption and bluish color of transmission shown by these three metals is similar to the colors shown by water, as, according to Prof. Forbes, the steam of a locomotive at a certain stage of condensation is blue or red according as it is viewed by reflected or transmitted light. The red color of clouds of an evening when the temperature has fallen considerably and the vapor of water in the air is condensed is also a case in point.

A recent experimenter has declared, in the Comptes Rendus, that certain salts of copper absorb the whole of the invisible heat (infra-red) spectrum, which we would expect them to do if copper is simply condensed water. Copper salts have no such effect on the visible and ultra-violet spectrum, however. I have seen no record of experiments in regard to the salts of silver and gold, and my object in writing this article is to bring the matter to the attention of those who have the time and the means to make experiments along the lines indicated herein.

The object-glass of an astronomical telescope may be covered with a thin layer of silver, which will reflect the heat and some light, allowing a pleasant greenish light and some chemical rays to pass, which we would expect to be the result if silver is condensed water.

Furthermore, certain facts in regard to the places of production of copper, silver and gold serve to substantiate the position I take. Copper is found in masses of many tons in weight, in a state of great purity, along the southern shore of Lake Superior, at a point where during the glacial age (according to geologists) the pressure of the snow and ice drifting southward was so great that it gouged out that great lake known as Lake Superior. This copper deposit (and also all copper deposits in this country) is contained between the walls of hard rock (crystalline traps) that withstood to a great extent the grinding force of the glaciers. Now water has been submitted to a pressure of 2,000 atmospheres (by Perkins) and condensed about one-twelfth of its bulk, and it is not unreasonable to suppose that the enormous and long-continued pressure of that great ice drift was sufficient to condense water, ice or snow between these granite walls, so that it became as dense as copper, or denser. It would be absurd to suppose that if water was compressed about one-seventh of its bulk it would go back to its original density when the pressure was released. Native silver to a large extent is present with the copper throughout the Lake Superior copper region, and always as a distinct and separate metal, occurring in macules and strings upon and through the copper. Surely this is not a mere coincidence.

Another fact tending to confirm the impression that copper, silver and gold contain hydrogen and oxygen is that hydrogen is strongly repelled by a magnet, while oxygen is strongly attracted; and as these diamagnetic and paramagnetic forces are shown also in compounds, we find that water, composed of two atoms of hydrogen and one of oxygen, is slightly repelled by a magnet—copper, silver and gold are also slightly repelled.

These three metals have but slight affinity for oxygen, as we would expect. One atom can only unite with one atom of oxygen, the oxygen being easily separated from them. In this regard they resemble hydrogen peroxide, H_2O_2, which so readily parts with oxygen and forms water, H_2O.

With respect to solution and the theory that "like dissolves like," we find that an allotropic form of silver is freely soluble in water, and that these metals are soluble in acids which contain dissociated hydrogen and oxygen ions.

Water, it is said, is a very poor conductor of heat, but it is conceivable that if the particles of water were close together, as in these metals, there would be great conductivity for heat—there can be no conduction without absorption.

Then there are metals such as iron, cobalt, manganese, and a few others, which show strong evidence of containing a large amount of oxygen in their make-up, because of the considerable transparency for the ultra-violet rays when glass is tinted with these metals and when in solutions, and because of their strong attraction for a magnet—similar to oxygen. It is also probable that they contain little or no hydrogen, from the fact that thin films of these metals transmit very little light and show great retardation and small velocity of light as compared to such metals as copper, silver and gold, which three metals Kundt found had but small refractive power and consequent high velocity of light. It is also probable that iron, cobalt, manganese, etc., contain carbon, because of their small conductivity for heat as compared with other metals.

Spectrum analysis shows that the element lithium is very similar to hydrogen, and from all the facts obtainable I consider that sodium is lithium plus oxygen (7 + 16), and that potassium is sodium plus oxygen (23 + 16), as has been pointed out before by others.

It is not probable that carbon, hydrogen and oxygen atoms or particles are the ultimate constituents of all matter, as recent scientific developments show that one kind of matter, called corpuscles, may be the material out of which all the atoms are built—a sort of a "one in three" and "three in one" arrangement, a conception such as we have of the Creator of the universe. Theologians would perhaps not indorse the idea herein set forth, that some of the chemical elements have been built up on this earth subsequent to its foundation, as they—theologians—would have us believe that the world and everything in it was created in much the same condition as at present. There is no reason, however, why religion and science should disagree, as they both claim to disseminate truth; and if theologians will consider well certain facts in chemistry and physics, I believe they will find that religion and science do not disagree to any great extent. Notice, for instance, that most of the chemical compounds contained in plants and animals may be put in one or other of two great divisions, carbon compounds or nitrogen compounds. These carbon compounds, in which carbon occupies the center of the stage, so to speak, are mostly of pleasant odor and taste, when they have any odor or taste—all the sweet odors from essential oils being oxygenated hydrocarbons, the hydrocarbons themselves being odorless; while most of the unpleasant odors and tastes can be ascribed to the nitrogen compounds, in which nitrogen occupies the center of the stage, so to speak. It is only necessary in some compounds to take the carbon atom from the center of the molecule—by the application of heat—and put nitrogen in its place, to produce a vile-smelling compound out of a sweet-smelling one, and vice versa. There is also reason to believe that sulphur, phosphorus and arsenic, and other elements which produce evil-smelling compounds, contain the element nitrogen. In fact the Scientific American of March 30, 1901, contained an account of the formation of arsenic from phosphorus, nitrogen and oxygen. Moreover, certain nitrogen compounds known as alkaloids, cocaine, nicotine, caffeine, theine, etc., are enslaving people all over the world and slowly but surely making them physical and mental wrecks. When we see the moral degradation caused by some of these alkaloids, are we not justified in believing that his satanic majesty works on us mortals through certain kinds of matter? It is absurd to suppose that the power of good and evil which we call God and Devil operate on man without the coöperation of matter, and it is reasonable to suppose that the good principle would work through certain forms of matter and the evil principle through others.

Of the three elements, carbon, hydrogen and oxygen, carbon may be said to be the central and most important element, as the Father is said to be the head of the Trinity; and any one with a slight amount of imagination who considers the mysterious part played by the hydrogen ions in acid solutions, known as catalytic action, and other important parts played by hydrogen, and elements such as sodium, potassium, etc.—which there is good reason to believe contain a large amount of hydrogen—and also the part played by oxygen, will see a similarity between their workings in the natural world and the workings of what we call the Second and Third Person of the Trinity in the moral world.

Then there are *three* classes of rays which come to us from the sun, and with a little imagination a similar relation may be observed between this trinity and the other. Experiments show that the chemical rays penetrate the earth and start the seeds to germinating, while the Third Person of the Trinity is supposed to start the seed of goodness to growing in man; then when the seed has germinated and the plant has reached the light, the rays known as light rays get in their work and decompose carbonic acid gas and build up the plant. The heat rays appear to be the main ones, inasmuch as they are necessary in all operations of nature, and are particularly necessary for the formation of flowers and fruit.

Chicago, Ill. William Schusiter.

A SILENT CHAIN GEAR.*

By J. O. NIXON, Philadelphia, Pa., Junior Member of the Society.

1. THE advantages of chain gearing for power transmission have long been recognized by the engineer, and since the introduction of the Ewart detachable link-belt in the early seventies, the use of drive chains has steadily increased, until now many million feet of driving chain are made and sold every year.

2. While the field in which this immense quantity of chain is used is necessarily very large, it is only a small part of the whole realm of power transmission. The reasons why chain gearing has been thus limited in its application are:

First.—The noise heretofore inseparable from all chain gearing.

Second.—The comparatively low speed limits.

Third.—The more or less rapid increase of noise

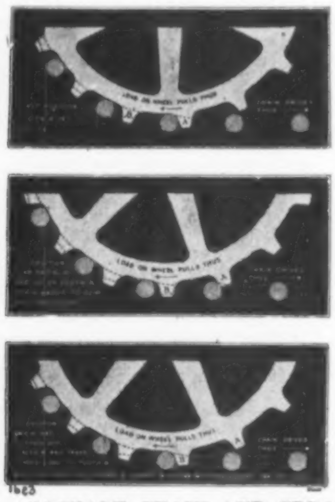


FIG. 1.—ORDINARY CHAIN AND SPROCKET.

and jar due to the stretch and wear of the chain and the wear of the wheel.

These three defects, inherent in all ordinary chains, are due to the stretch of the chain, by its elasticity and by wear, both internal and external, which make a chain, as soon as it is started up, too large for the sprocket which it was made to fit.

Fig. 1 will possibly make this clearer. The figure shows a driven sprocket wheel and a chain of the ordinary type. This chain, it is assumed, was made to fit the sprockets. However, as soon as the gear was started up, the pitch lengthened so that this is no longer the case. This lengthening of the pitch, or stretch, is due to the following causes. The pins bed in their bearings, the stress on the chain stretches the metal, which is, of course, elastic, and wear of the pins and of their bearings begins at once and is a constantly increasing factor. Add to this the decrease in root diameter of the sprocket due to wear, and we have the conditions shown in the figure, of a wheel running with a chain which is too big for it. This

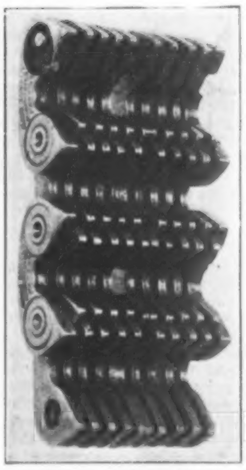


FIG. 2.—STAMPED CHAIN.

FIG. 3.—BLOCK CHAIN.

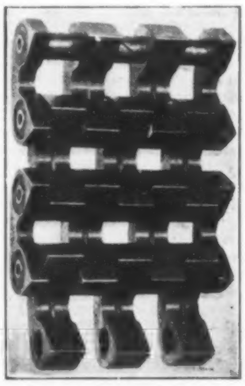


FIG. 4.—MULTIPLE BLOCK CHAIN.

means that one tooth alone is doing all the work at any given time.

3. In the first section of Fig. 1 we have tooth *A* in action; in the second section the wheel has revolved and the chain is about to slip off tooth *A*, and in the third section the chain has slipped off, and the wheel has slipped back under the influence of the load, until tooth *B* comes in contact with the chain. This slipping back of the wheel makes a noise and causes a shock to both chain and wheel. These shocks occur every time a link passes out of mesh and, therefore, at even very moderate speeds, the number per minute is very large. It has been proved by experiment and by practice that this jarring action is very wasteful of power, and that the amount of power consumed by it increases more rapidly than the speed increases, so that the allowable useful working stress becomes smaller and smaller with increasing speed. This limits the speed at which a chain may be run. Of course this limiting speed varies greatly for various styles of chain and is much higher for a steel roller chain of proper design than for a malleable chain. What has been said above with reference to a driven sprocket applies with equal force to the driver.

4. From the foregoing it will be immediately inferred that the solution of the problem of producing a *high speed* and a *silent* chain-gear lies in the production of a wheel and a chain which shall always remain a perfect fit each with the other entirely independent of the stretch of the chain. Such a chain gear has been developed by Mr. Hans Renold, of Man-

FIG. 5.—SILENT CHAIN AND SPROCKET.

chester, England, and has been in wide and successful use in Europe for some five years past. This chain gear consists of a chain composed of links of a peculiar form stamped from the sheet or cut from a drawn bar fastened together by shouldered rivets into a chain of any desired width (Figs. 2, 3 and 4) running over cut sprocket wheels with teeth of a shape varying with the size of the wheel. It is absolutely silent and may be run at high speeds. It is capable of transmitting any amount of power from the smallest to the greatest.

5. How the Renold chain gear accomplishes its results may be best seen by reference to Fig. 5. It will be noted at once that the chain has contact with the wheel on the faces of the teeth only, and not on the root circle at any time. The flat bearing surfaces of chain and wheel at corresponding angles cause the chain to take the form of a perfect circle at all times, with a pitch diameter corresponding to the pitch of the chain, and not the pitch of the wheel, as in the case where the bearing is on the root circle. Because of the above, every tooth in mesh is in equal contact with the chain, and remains so whatever the stretch. As any given tooth goes out of contact with the chain there is no slipping back of the chain, for the next, and every other tooth in mesh, is in perfect working contact with it. Thus there is no noise connected with the operation of the chain, and the cause which limits the speed of the ordinary chain gear does not exist. The first section of Fig. 5 shows a new chain on the sprocket; the second section shows the same chain after having stretched, and illustrates how the chain automatically adjusts itself to the sprocket, remaining always a perfect fit for it; the third section shows the rolling action of the chain as it comes into mesh. There is seen to be no sliding of the chain on the sprocket tooth, which means, of course, minimum of wear and maximum of efficiency. The Renold silent chain gear, as Mr. Renold has named this development, is therefore noiseless; it can be run at high speeds; and it retains the originally perfect action until worn out. Another valuable property, which is a corollary of the self-adjusting feature of the chain, is the possibility of running two or more chains side by side on the same wheels. In this way, when large powers are to be transmitted, and the width of chain necessary becomes too great for convenience in manufacture or in handling, several chains may be used with the perfect assurance that each will bear its proper share of the load. This is in great contrast to the known impossibility of getting two ordinary chains to stretch evenly and so distribute the load between them. As the number of chains becomes greater the difficulty by the old method is more than proportionately increased.

6. The life of a chain is the length of time which it will take to stretch it so much that it ceases to have any bearing whatever on the teeth of the sprocket wheels. A very small bearing will suffice, because the load is divided between all the teeth in mesh. Hence, to prolong the life of the chain, the steel used in its manufacture must be of the very highest grade obtainable, and it must be worked with the utmost accuracy. A steel for the links of high tensile strength allows the use of pins or rivets of large diameter while preserving the tensile strength of the chain as a whole. The large bearing surface so obtained is rendered yet more valuable by the use of hardened pins of high grade material. The washers on the ends of the rivets claim no little attention. They must be small in diameter and not too thick. This necessitates a steel of high tensile strength and elasticity, so that the washer shall grip the rivet end when it is forced over it and still, by its small size, not add to the bulk nor detract from the appearance of the chain.

From the question of material one naturally passes to the allowable limits of error in workmanship. In a general way it may be said that the chain should be as accurate as it is possible to make it. The pitch must be accurate, the holes must be properly located, and the rivets must be neither so short as to bind the links nor so long as to give excessive play.

7. The sprockets used with the silent chain form, of course, an indispensable part of the gear. They must be accurately cut with special cutters and may be of any material. The teeth have straight sides to give a full bearing with the working surfaces of the chain. The angle of the tooth is different for every diameter of sprocket; or, to put it in another way,

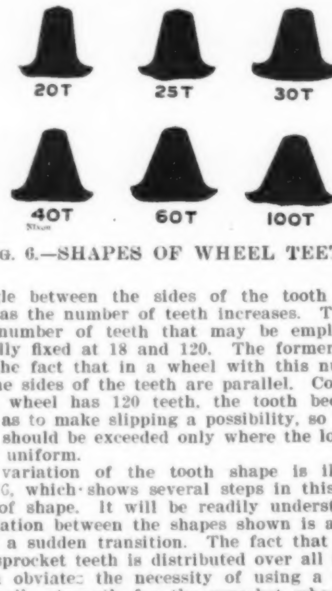


FIG. 6.—SHAPES OF WHEEL TEETH.

the angle between the sides of the tooth becomes greater as the number of teeth increases. The limits to the number of teeth that may be employed are practically fixed at 18 and 120. The former limit is set by the fact that in a wheel with this number of teeth, the sides of the teeth are parallel. Conversely, when a wheel has 120 teeth, the tooth becomes so blunted as to make slipping a possibility, so that this number should be exceeded only where the load is absolutely uniform.

This variation of the tooth shape is illustrated in Fig. 6, which shows several steps in this gradual change of shape. It will be readily understood that the variation between the shapes shown is a gradual and not a sudden transition. The fact that the load on the sprocket teeth is distributed over all the teeth in mesh obviates the necessity of using a metal of high tensile strength for the sprocket wheels. The fact that there is no sliding of the chain on the sprocket teeth obviates the necessity of using a very hard metal to minimize wear. It is therefore possible to make a strong and durable sprocket wheel of cast iron. Steel, however, has been used for the small wheel on automobiles, and in other cases where the service was particularly severe. The flanges are put on after the teeth are cut, and are either shrunk on, or riveted to the wheel.

8. With regard to the practical use of the chain the following points may prove of interest: It is obviously necessary that one wheel of the pair be flanged to prevent the chain running off; it has been found that better action is obtained where the driven wheel is flanged; the chains may be run with the sprockets so close together as to barely clear, or the drive may be of any length up to ten or fourteen feet without supporting idlers and, if such support be used, may be of any length found economical and desirable.

The only factor so far found which serves to limit the speed is the difficulty of keeping the lubricant on the chain at very high speeds. At speeds exceeding 1,350 to 1,400 feet per minute, the oil is thrown off by centrifugal force, but speeds as high as 2,300 feet have been employed successfully by inclosing chain and wheels and running them in oil. The particular case in mind was the transmission of 75 horse power from the motors to the car axle on the mono-rail railway at the Brussels Exhibition. This is the type of road which is soon to be erected between Liverpool and Manchester.

This is by no means the only case where high speeds have been attained by inclosing the gear, but is simply cited as typical. In this connection, however, it may be well to call attention to the fact that the chain speeds being lower than the speeds necessary for belting, allows sprockets of correspondingly smaller

* Presented at the New York meeting (December, 1901) of the American Society of Mechanical Engineers, and forming part of Volume XXIII. of the Transactions. For previous discussions on this and related topics consult Transactions as follows: No. 198, vol. vii., p. 273: "Experiments on the Transmission of Power by Gearing," Wilfred Lewis. No. 202, vol. vii., p. 347: "Transmission of Power by Belting," Gaetano Lanza. No. 213, vol. vii., p. 549: "Experiments on Transmission by Belting," Wilfred Lewis. No. 436, vol. xii., p. 230; "Rope Driving," C. W. Hunt.

diameters for the same angular velocities. The chain thus effects a marked economy of space, not only in the diameter of the wheels, but because of the comparatively long centers absolutely essential with belting. The line of centers may be horizontal, inclined, or vertical, provided that the shafts are parallel, but there are two limitations on vertical drives. The small wheel should not be the upper one, because the weight of the chain crowds it into the sprocket and gives bad action. Some form of tightening device should be provided, either by adjusting the centers, or by an idle roller on the slack side of the chain, so as to prevent the chain, when it stretches, from falling away from the lower sprocket. Both of these troubles may be obviated by inclining the line of centers.

Wherever the chain gear is exposed to dust or grit of any sort, it should be inclosed in a dust-tight casing. In any case, a light metal guard should be provided to prevent anything falling into the gear.

9. The statement was made in the beginning of this paper that the causes which have heretofore limited the use of chain gearing were the speed limit, the noise, and the more or less rapid deterioration of the action of chain and wheels. We have now seen how these three defects have been eliminated in the Renold silent chain gear, and this question naturally arises: "To what is the silent chain gear especially applicable, and how has it proved its usefulness in the past?" An answer to the latter half of this question will also be the best answer to the first half.

It is hard to name a branch of the mechanical world in which the silent chain has not made a permanent and honored place for itself. It has been used on machine tools in numberless ways; it forms an integral part of many special machines; it drives shallow-draught gunboats on the Nile, and heavy gun lathes in Sheffield. Engine governors are driven by it, and the motors whose power is transmitted through this medium are hundreds in number and of all sizes, from the smallest to the largest. Builders of automobiles of all types have found that the silent chain offers a solution of their difficulties, and it is in use to-day on hundreds of cars, from the light three-wheeled pleasure carriage to the heavy steam truck. In our own country, Messrs. Brown & Sharpe have been using this chain for some time for driving the spindles and feeds on their machines. The new factory of the Natural Food Company, at Niagara Falls, is driven throughout by silent chain. Here the service is severe because of the sudden start and quick acceleration, under load, of the induction motors used. The drives vary in size from 1 to 40 horse power. These are only notable instances, for already the chain is in use in many varieties of service on this side of the water. Figs. 7, 8 and 9 show applications of the chain. The data as to these transmissions are given under the figures themselves.

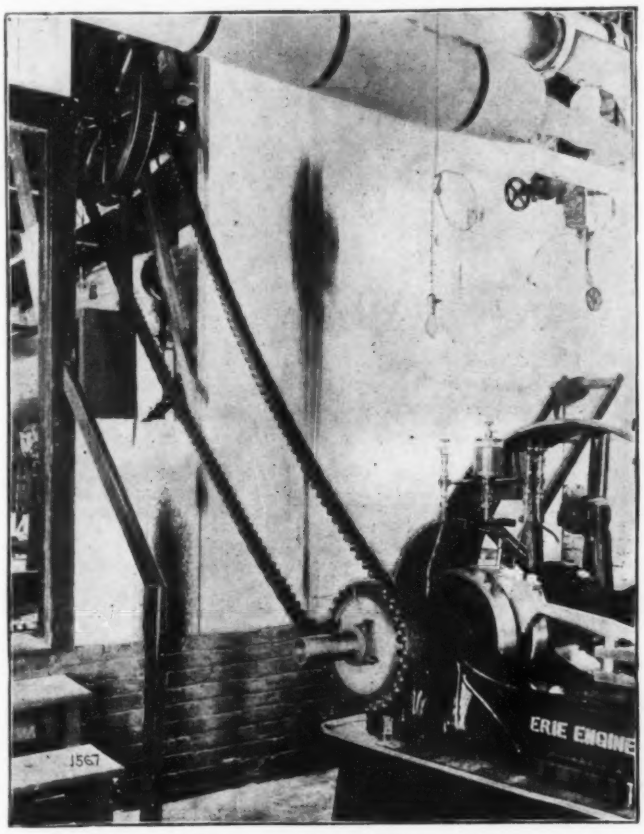


FIG. 7.—CHAIN DRIVE, 25 HORSE POWER ENGINE TO LINE SHAFT, CHAIN SPEED 900 FEET PER MINUTE.

10. To sum up.

The Renold silent chain gear possesses, in common with all chain gears, these advantages:

(1) A positive speed ratio (no slip).

(2) No tension in the slack side of the chain and, therefore, a minimized loss in journal friction.

(3) Adaptability to short centers or to long centers.

(4) Adaptability to hot or damp situations.

In addition to these it possesses the following unique advantages:

(1) It is silent.

(2) It may be run at high speeds.

(3) The initially perfect action is preserved throughout the life of the chain.

(4) The load is distributed over all the teeth in mesh.

It is superior to leather or rubber belts because—

(1) It provides a positive speed ratio.

(2) There is a minimum loss in journal friction.

(3) It can be used in hot or damp situations.

(4) It can be used on short centers without a troublesome and wasteful idler.

It is superior to spur gearing because—

(1) It is noiseless.

(2) It does not require fixed centers.

(3) It does not require short centers.

(4) There is no sliding friction on the teeth, hence it is more efficient.

(5) It is smoother in action and generally more durable.

The writer believes that no one who has given the subject even casual thought will dispute the assertion that the development of the Renold silent chain gear marks an era in the history of power transmission.

FIG. 8.—10 HORSE POWER DRIVE ON STAIR LIFT, CHAIN SPEED 1,070 FEET PER MINUTE.

FIG. 9.—7 HORSE POWER CHAIN DRIVE ON SELLERS GRINDER, CHAIN SPEED 1,000 TO 1,800 FEET PER MINUTE.

THE POSTAL SERVICE.

THE annual report of Postmaster-General Smith for the fiscal year ended June 30, 1901, has been made public. The financial operations of the department are shown in the following statement:

Ordinary postal revenue	$109,531,778.67
Receipts from money order business	1,668,659.29
Receipts from unpaid money orders more than one year old	430,755.43
Total receipts from all sources	$111,631,193.39
Total expenditures for the year	115,554,920.87
Excess of expenditures over receipts	$3,923,727.48

While the expenditures in the ordinary development and through various extensions of the service are $7,814,652.88 greater than for the preceding year, the deficit is $1,461,961.22 less. Under present prosperous conditions the annual increase of receipts is larger than the increase of outlay, and for several years the deficit has been steadily growing smaller.

The estimates for the fiscal year ending June 30, 1903, are as follows:

Total postal revenue for 1901	$111,631,193
Add 9 per cent for estimated increase year ending June 30, 1902	10,046,807
Estimated revenue for 1902	$121,678,000
Appropriation for the postal service for 1902	123,782,688
Estimated deficit for 1902	$2,104,688
Estimated revenue for 1902	$121,678,000
Add 8½ per cent	10,342,630
Estimated revenue for 1903	$132,020,630
Estimated expenditures for 1903	134,731,576
Estimated deficit for 1903	$2,710,946

ABUSES IN SECOND CLASS MATTER.

The Postmaster-General devotes much space to a review of the abuses in second class matter and the measures taken to reform them. On this subject he says, in part:

In my annual report for 1899 I said: "The most urgent need of the postal service is the rectification of the enormous wrongs which have grown up in the perversion and abuse of the privilege accorded by law to second class matter." Time and experience only emphasize this statement. It is the most urgent need, because it aims at the one great overshadowing evil of the service, and because it underlies and overtops all other reform and advance. It would relieve the department from the one oppressive burden which cripples and weighs it down, and which stands as a constant and formidable barrier against improvement and progress for the benefit of all the people in many directions. Deeply impressed with this conviction, the department has taken positive steps, in orders issued on July 17, 1901, to correct the abuses and accomplish substantial reform, so far as it is possible by administrative action.

In dividing mail matter into four classes the law provides that newspapers and periodicals coming within the conditions it prescribes shall constitute the second class, with a postage rate of one cent a pound. All other printed matter, including books,

circulars and advertising sheets, constitutes the third class, with a postage rate of one cent for two ounces. The law defines the characteristics which shall distinguish and determine second class matter, and it intends to limit the privilege and benefit of the pound rate to legitimate newspapers and periodicals which fulfill these statutory requirements. But, in fact, thousands of publications which are in reality books or purely advertising sheets or gift enterprises, and which the law never meant to include within the second class, have crept in through evasions and loose constructions until this abuse has grown to colossal proportions and imposes a burden of many millions of dollars a year on the government and the people.

The second class matter constitutes nearly 60 per cent of the weight of the entire mail of the country, and yet, while the postal revenue for the last fiscal year was $111,631,193, the second class matter paid only $4,294,445 of that amount—that is, while making three-fifths of the mail in weight, it furnished only one twenty-eighth part of the revenue. The transportation of the mails is paid for chiefly by weight. The enormous disproportion of return to cost in second class matter is thus apparent at a glance.

If the mail thus carried at a heavy loss were limited to what the law intended, there would be nothing more to be said. In that case it would be a deliberate and rational public expenditure for a well defined, justifiable and worthy public object, and taking the service as a whole there would be no loss at all. Our free institutions rest on popular intelligence, and it has from the beginning been our fixed and enlightened policy to foster and promote the general diffusion of public information. . . . But in adopting this special rate for a legitimate public end Congress has sought to restrict its privilege to legitimate publications with a manifest public aim and a clear public demand. It never meant to open the floodgates for an inordinate stream of purely private enterprises which have no public object whatever within the contemplation of the law, and which have seized upon the low rate of postage solely for private profit at the public expense.

Of this vast mass of second class matter it is estimated that one-half does not come within the meaning and intent of the law and is not rightfully included in that class, and thus is not entitled to be mailed at the pound rate. If it be difficult at first to believe that the proportion of wrongly classed matter is so large, two considerations will make it clear. On the one hand, the entire circulation of the questionable matter goes through the mails, for with its scattered range it has no other method of distribution. On the other hand, the great body of the newspapers of the considerable cities, where requiring transportation, go for the most part in bulk on the railroads outside of the mails. Most of their circulation is within a radius of two hundred or three hundred miles. Within that circle they are transported in bulk for less than the postage rate. The government carries for three thousand miles at the same rate as for three miles. If the abuses now under consideration can be eliminated it will be entirely feasible to establish zones with graduated rates, and to carry newspapers and periodicals in bulk within a limited radius for half a cent a pound. But, as the case now stands, and with a just understanding of these facts, the estimate will be readily accepted that one-half the volume of second class mail is of the character which the law never intended should possess its privilege.

To correct the various abuses thus indicated, the department has undertaken a more strict application of the law, through three orders directed to the several objects which have been described. The full results of the reform will not be realized at once. It is first necessary to enforce the lawful classification, which is a work of some time. This will either relieve the mails or bring more revenue, or do both. The postal force, both in the post-offices and on the railroads, will also be measurably relieved of the excessive strain now placed upon it, and if it cannot be diminished it will at least gain more freedom for better service in other directions, and the constant and urgent pressure for an increase in order to keep pace with the heavy demands will be lessened. The cost which the abuses have entailed on the government can be approximately calculated, but the saving depends on the degree of thoroughness with which the reform can be executed, and cannot be accurately estimated. It will, however, when fully realized, amount to several million dollars a year, and will not only make the service self-sustaining, but permit important advances on other lines.

RURAL FREE DELIVERY.

The rural free delivery has advanced with increased strides. Its extension in the last year has been nearly three times as great as the whole amount of service previously established. The number of routes in operation at the beginning of the fiscal year was 1,276, and at the close 4,301. During the current year, with an augmented appropriation and a more experienced force, the work will proceed still more rapidly. At the opening of December 6,009 routes will be running, and under present plans the number will increase by July 1, 1902, to 8,600.

The rural population now receiving daily service is about four millions, and at the end of the fiscal year it will reach 5,700,000. The delivery system will then cover more than a quarter of the eligible portion of the country, and at the present rate of establishment the entire area suited to the service—that is, as estimated, a million square miles of territory, with 21,000,000 of rural residents—will be brought within its scope in less than four years. The mail will then, if the work goes on, be delivered at every door in the United States except in the most remote, mountainous and sparsely settled sections, and in villages of limited receipts where the post office is within easy reach. The number of applications for new routes at this time last year was 2,159. Those now pending and awaiting action amount to 6,129.

THE PNEUMATIC TUBE SERVICE.

The pneumatic tube service in New York, Philadelphia and Boston was suspended with the close of the last fiscal year. The contracts then expired—Congress failed to make further appropriation, and the service ceased. A strong public appeal came for its continuance, and proposals were made looking to that object without expense to the government. But the department accepted the attitude of Congress as decisive of its desire and purpose, until it could review the question. It would be unfortunate, however, in the judgment of the department, if the suspension were more than temporary. Delays have ensued in the transmission and delivery of the mails, and the business interests which have been injuriously affected earnestly seek the re-establishment of the service. The report of the expert commission appointed in 1900, which was transmitted to the last Congress, and to which attention is again invited, was a searching exposition of the subject, and fully upholds the pneumatic system, within defined limits, as an important, valuable and necessary accessory of mail communication. To strain fast mail trains and then partially defeat their object by slow wagon service at the great terminals is a contradictory and incongruous policy. The department renews its request for an appropriation of $500,000 for the restoration of the pneumatic service, and I earnestly commend it to the favorable consideration of Congress.

CUBA AND THE PHILIPPINES.

The postal service in Cuba, under the reorganization effected last year, has been conducted with the highest degree of fidelity and efficiency. The revenue for the fiscal year 1900 was $246,912.31, and for the fiscal year 1901 it was $367,634.50, showing an increase of $120,722.19. This increase was due, not to an expansion of the postal business, but to a faithful accounting of moneys received. The expenditures for the fiscal year 1900 were $598,497.69, and for 1901 they were $451,437.89, showing a decrease of $147,059.80. The deficit was thus reduced from $342,585.38 to $83,803.39. These statements summarize the results of a careful and honest administration. Notwithstanding the large retrenchment of expenditures, the service has been greatly improved, and it is now in excellent shape for such disposition as the course of affairs in the island may require.

In the Philippine Islands the service has been somewhat extended as the general conditions have improved and the need for intercommunication has been increased. This extension has entailed larger cost, and the expenditures have, for the first time, passed the receipts, the deficit for the year being $36,470.06. Outside of Manila and the larger towns nearly all the revenue is derived from the army and the employés of the government. The Civil Service system is in full operation, and since September 19, 1900, all employes have been appointed after Civil Service examination. The need of a regular transportation service between the islands becomes more apparent with the return of normal conditions, and measures for the establishment of such service will receive careful consideration.

OCEAN MAIL SERVICE.

Under the act of 1891, to provide for ocean mail service between the United States and foreign ports and to promote commerce, six contract routes for ocean mail service are now in operation, at a cost of $1,448,968 per annum. The latest contract went into effect on November 1, 1900, and was with the Oceanic Steamship Company for carrying the mails from San Francisco to Sydney, New South Wales, calling at Honolulu, Pago Pago and Auckland. The importance of a more direct, speedy and regular communication with the Philippine Islands will be universally recognized. Such communication might be provided in connection with mail service to Japanese and Chinese ports, and its advantage to the commercial and general interests of the country is apparent. The promotion of a merchant marine and the illustration during the Spanish war of the value of the fast mail steamers as auxiliary cruisers in times of emergency enforce the wisdom of making the act for the extension of ocean mail service effective wherever it is practicable.

EXTENT OF THE SERVICE.

Money order transactions, the Postmaster-General says, amounted for the year to $294,618,680.99, an increase over the previous year of $39,000,000. The number of money order offices at the close of the year was 30,529, an increase of 880. The free delivery system in cities serves 32,000,000 patrons at a cost of 50 cents a year each. The length of domestic or inland mail routes was increased during the year by 10,818 miles, or 6,940,285 miles in annual travel, the total number of such routes of all classes at the end of the fiscal year being 35,316, aggregating 511,808 miles in length and an annual travel of 466,146,059 miles. This service involved an expenditure of $56,810,242.05, an increase of $1,664,182.29 over the previous year. The Alaskan service comprises twenty-nine routes, with a length of 22,059 miles, involving annual travel of 665,067 miles, at a cost of $293,046.99.

LEGISLATION RECOMMENDED.

The Postmaster-General makes the following recommendations for legislation:

That the maximum fee for a money order be fixed at 25 instead of 30 cents.

That a fund be created out of the salaries of railway mail clerks to provide for the retirement of such clerks as have, after long periods of service, become incapacitated for active duty.

That publishers be required to make a preliminary separation of newspapers, under the direction of the department, as a condition under which they shall enjoy the exceedingly liberal rates provided for carrying second class matter through the mails.

That Section 3 of the act of June 13, 1898, Chapter 446, providing that assistant postmasters, cashiers and other employés in post offices of the first, second and third classes shall give bond direct to the United States be repealed, and that a statute be enacted requiring such officers to give bond directly to the postmasters and holding postmasters responsible under their own bonds for any and all acts and defaults occurring at their respective offices.

That provision be made for the payment of incidental expenses incurred by local officers or others in the arrest, detention and keeping of prisoners charged with violations of the postal laws until such prisoners can be transferred to the custody of a United States marshal.

That a statute be enacted authorizing post office inspectors to take out search warrants whenever the same may be necessary in the prosecution of their official duties.

That the Interstate Commerce law be amended to prohibit common carriers, to wit, telegraph and express companies, or any of their employés, from aiding and abetting in the greengoods or lottery swindles, or any other schemes carried on partly by mail and partly by common carrier, and which are in violation of the postal laws.

SELECTED FORMULÆ.

Handkerchief Perfumes.—

	Grammes.
Acacia essence	1000
Jasmin essence	250
Tuberose essence	250
Extrait de roses triple	250
Bitter almond oil	5
Civet essence	120

Ess. Bouquet.—

Spirit	8000
Distilled water	2000
Iris tincture	250
Vanilla-herb tincture	100
Benzoin tincture	40
Bergamot oil	50
Storax tincture	50
Clove oil	15
Palmarosa oil	12
Lemon-grass oil	15

Spring Kisses (Baisers du Printemps).—

Rose essence	2500
Violet essence	2500
Esprit de roses triple	300
Acacia essence	100
Jasmin essence	200
Ambra essence	80
Bergamot oil	10
Lemon oil	2

Heliotrope.—

Spirit	4000
Water	500
Musk tincture	50
Benzoin tincture	30
Iris tincture	100
Vanilla-herb tincture	100
Clove oil	30
Lavender oil	15
Lemon oil	15
Bergamot oil	30
Geranium oil	15

Cedar (Cèdre du Libanon).—

Rose essence	1000
Spirit	2500
Cedarwood oil	400

Jockey Club.—

Spirit	4000
Water	500
Musk tincture	60
Bergamot oil	60
Tonca beans essence	60
Clove oil	30
Cassia oil	10
Palmarosa oil	20
Lavender oil	15

Rose.—

Spirit	4000
Water	1000
Rose essence	2000
Tuberose essence	1000
Orange (second extract)	1000
Bergamot oil	10
Geranium oil	15
Rose water	400
Clove oil	5

Bouquet d'Irland.—

White rose essence	5000
Vanilla essence	450
Rose oil	5
Spirit	100

Lily of the Valley.—

Acacia essence	750
Jasmin essence	750
Orange flowers essence	800
Rose flowers essence	800
Vanilla flowers essence	1500
Bitter almond oil	15

Ylang-Ylang.—

Spirit	4000
Water	1000
Iris tincture	75
Vanilla-herb tincture	60
Musk tincture	30
Sandalwood oil	6
Linaloe oil	20
Palmarosa oil	15
Clove oil	6

Kiss Me Quick.—

Spirit	4000
Water	1000
Cassia essence	1000
Geranium oil	8
Cedarwood oil	5
Clove oil	4
Bergamot oil	5

Queen Victoria Perfume.—

Orange flowers essence	600
Tuberose essence	1250
Violet essence	2500
Rose essence	2500
Civet essence	100
Acacia essence	300
Bergamot essence	25
Lemon oil	10

Eau de Mille Fleurs.—	
Acacia essence	500
Ambra essence	250
Cedar essence	250
Jasmin essence	50
Tuberose essence	250
Violet essence	500
Vanilla essence	500
Rose essence	300
Orange flowers essence	250
Esprit de roses triple	1000
Clove oil	2
Neroli oil	2
Rose oil	2
Bitter almond oil	5
Bergamot oil	40

Mignonette.—	
Spirit	4000
Water	1000
Mignonette essence (second extract)	2000
Vetiver tincture	40
Vanilla-herb extract	30
Abelmusk tincture	30
Bergamot oil	50
Geranium oil	25
Clove-cinnamon oil	3

Jessamin.—	
Spirit	4000
Water	1000
Jessamin essence (second extract)	2000
Jessamin oil	30
Bergamot oil	30
Linaloe oil	20

Heliotrope.—	
Spirit	4000
Water	1000
Palmarosa oil	40
Clove-cinnamon oil	10
Lemon oil	35
Lavender oil	10
Vanilla-herb tincture	100

—Private recipes of Alwin Engelhardt, in Neueste Erfindungen und Erfahrungen.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Influence of American Coal on the International Market.—For some time past the German press has been pointing out the danger threatening the European coal industry through the introduction of the American product. Some German writers have prophesied a complete transfer of the source of supply of coal for the international market. Dr. Wiegand, general manager of the North German Lloyd Steamship Company, recently gave an interview on this subject to the editor of Kirchhoff's Technische Blätter.

Dr. Wiegand is of the opinion that the American coal will not exercise an immediate influence on the European coal market, but will doubtless affect it within a reasonable space of time. A direct importation of American coal to North European ports on a large scale is considered by him to be out of the question, for the reason that the extra cost of sea freight would more than counter-balance any advantage possessed by the American coal due to the lower cost of mining. This sea freight will remain comparatively high for the export of American coal, because the American coal steamers cannot count on return freight to the United States from Europe, and the coal cargo would therefore have to cover the expenses of the voyage from the United States to the European ports, as well as the costs of the return trip. In ports which are accessible to European coal by water shipment only, the price of the coal would naturally be increased by the cost of the sea freight; but even here the United States would be at a disadvantage as compared with England, as larger quantities of staples are imported into that country, and the coal steamers could consequently be reasonably certain of a return cargo; while the steamers in our trade—pre-eminently a country of export—would generally find no cargo for their home voyage.

During the past few years American coal has been exported to Mediterranean ports. It can safely be assumed that this export will make considerable progress, and the time will come when American coal will make its appearance in sharp competition with the English product in Genoa and Port Said and other markets of the Mediterranean Sea. The same applies to all the ports of the eastern coast of South and Central America, since some of them, at least, could provide a return cargo to the United States. This forced reduction of the exportation of English coal to these markets would result in a decrease in the price of the English coal there, and at the same time would affect the price of German coal.—Jay White, Consul at Hanover.

Competition for Military Tractor in Great Britain.—The Department has received from the British embassy, Washington, under date of November 25, 1901, copy of a notice of a competition for military tractors, to be held in the spring of 1903. An invitation is extended to manufacturers of such vehicles in the United States to take part in the competition, and the embassy requests that a notification thereof be published in the Consular Reports, as was done in the case of the competition for self-propelled lorries,* in order that it may become widely known among manufacturers at an early date. The regulations are:

TRACTOR FOR MILITARY PURPOSES.

(1) It being essential that tractors for military purposes should be capable of a much greater radius of action, without replenishment of fuel or water, than is at present attained by any such engines constructed for either military or commercial purposes, the Secretary of State for War offers prizes, as under, for the best tractors meeting the requirements mentioned hereafter:

First prize	£1,000 =	$4,866.50
Second prize	750 =	3,649.87
Third prize	500 =	2,433.25

To each prize will be added a bonus of £10 ($48.66) for every complete mile beyond the minimum of 40 miles required by paragraph 2 of the "requirements" that the tractors awarded such prize can travel under the conditions therein described. The total amount of this bonus shall not exceed the value of the particular prize to which it may be added.

(2) The trials, which will be conducted by the War Office committee on mechanical transport, will commence in the spring of 1903, and will extend over a considerable period, so that the tractors may be thoroughly tested. The exact nature of the trials will be determined upon by the above committee. A general scheme will be drawn up and issued to all competitors, but the committee reserve to themselves full powers to carry out any additional tests that they may deem necessary, whether included in the general programme or not. The committee reserve to themselves the power of rejecting any tractor which does not comply with the requirements published herewith, or of suspending, at any stage, the trials of any tractor which in their opinion has proved itself unsuitable.

(3) The decision of the committee on all matters connected with the competition shall be final.

(4) Forms of entry will be supplied on application to the secretary, mechanical transport committee, War Office, Horse Guards, Whitehall. Firms or individuals who intend to enter must send in these forms, duly completed, to the secretary, not later than January 1, 1903.

(5) No tractor will be admitted to the trials unless a fully dimensioned set of drawings and a specification, giving complete details, exactly as submitted for trial, together with a statement of the purchase price, have been lodged with the secretary of the mechanical transport committee before the commencement of the trials.

(6) A firm or individual may enter more than one tractor, but the conditions of paragraphs 4 and 5 must be complied with for each separate machine entered.

(7) His Majesty's Government to have the right of purchasing all or any of the competing tractors at the price stated by the competitor under paragraph 5.

(8) All designs and specifications lodged under paragraph 5 will be considered confidential; and those of the tractors that may be purchased will be retained for the purposes of the government, but without prejudice to patent rights. Those of the tractors not purchased will be returned to the competitors after the trial.

STATEMENT OF REQUIREMENTS OF TRACTOR FOR MILITARY PURPOSES.

(1) Not to exceed a gross weight of 13 tons when fully loaded with all its fuel and water and with all stores necessary for its proper manipulation on the march, and must be independent of any extraneous machinery for the supply of its motive power.

(2) To be capable of hauling a gross load of 25 tons for not less than 40 miles over ordinary roads, having, so far as may be possible, grades not exceeding approximately 1 in 18, at an average speed of 3 miles an hour without at any time exceeding a speed of 5 miles an hour, using only the fuel and water that can be carried on the tractor itself, without being replenished during the journey from either a separate vehicle or from any other source, and, in the case of a steam engine, without reducing the amount of water in the boiler below a safety level to be fixed by the committee.

(3) To be capable of hauling a gross load of 12½ tons along a good, level road for a distance of not less than 1 mile at a speed of 8 miles an hour.

(4) To be capable of hauling a gross load of 12½ tons up a slope of 1 in 6 (for this test the tractor can be fully loaded with fuel and water).

(5) To be so designed and constructed that it shall be capable of traveling on all classes of roads and over rough ground without excessive wear and tear or injury, either from shock or from any of its lower portions striking obstacles projecting from the surface of the ground or from the wheels sinking into the ground in soft places, or from other causes, and to be capable of being driven through water 2 feet deep without its motive power being seriously affected.

(6) To be capable of being driven either ahead or astern.

(7) To be fitted with efficient brakes on all driving wheels.

(8) To be efficiently spring mounted on all axles.

(9) Provision must be made for rapidly locking together each or every pair of driving wheels.

(10) To be capable of being steered by one man, and entirely controlled and manipulated by not more than two men, who must be placed in convenient positions for the work they are required to do.

(11) To be provided with adequate covering to protect the men from the weather.

(12) The handles, levers, or other arrangements for controlling the mechanism to be so arranged that the tractor may be driven either ahead or astern, changed from one speed and from one direction of movement to another, steered, have brakes applied, and have any oiling or adjustments, necessary while traveling, carried out without the driver or assistant (if employed) leaving his normal position.

(13) Proper arrangements to be made that no part of the machinery be liable to damage from mud or dust. When casings are used, these should be dust proof and readily removable for inspection and repair.

(14) To be fitted with a winding gear, carrying 75 yards of flexible galvanized steel-wire rope, 2¼ inches in circumference, the breaking strain of which must not be less than 15 tons, with suitable leading sheaves arranged so that a fair lead may be obtained for the rope from the drum to either the forward or after end of the tractor, and from thence in any direction within an angle of 90 deg. on either side of the fore and aft center line of the tractor; the winding gear to be arranged so that the wire rope can be paid out from the drum while the engine is moving ahead.

(15) The driving wheels to be not less than 6 feet 6 inches in diameter, nor less than 18 inches wide across the tires.

(16) To prevent the tractor being stopped by its weight being taken on under surfaces, should the wheels sink into the ground, the clearance between such under surfaces and the ground must not be less than 18 inches.

(17) Not to exceed the following outside over-all measurements: Height from the ground level, for the fixed parts of the engine, 9 feet; and for removable parts, such as chimney, roof, etc., 12 feet; width, 7 feet 4 inches; length, 20 feet.

(18) No restrictions are placed on nature of fuel or class of engine—whether steam, internal combustion, or otherwise—except that oils having a flash point of less than 75 deg. F. (Abel's close test) must not be employed.

(19) As the tractor is intended primarily for hauling purposes, it is not essential that a flywheel should be provided from which machinery can be driven by a belt; but if a flywheel is fitted, it must be made of steel.

(20) No armoring need be arranged for.

(21) In the case of steam engines—

(a) The boiler may be of any form or material, but the construction must be such that it will comply with the requirements of the Manchester Steam Users' Association. Boilers normally working at exceptionally high pressures are not desirable.

(b) The boiler must be so designed that it can be easily washed out.

(c) An efficient arrangement must be fitted for preventing the emission of sparks from the chimney.

(d) The boiler feed apparatus must be in duplicate.

(e) A reliable water lifter for filling the engine tanks must be fitted.

(f) If coal fired, means must be provided to deal with fuel that clinkers freely, and the grate area must be sufficient to enable coal of a very inferior quality to be used.

(g) If condensing apparatus is employed, it must be substantially constructed, and not liable to damage from vibration or to be clogged up by dust.

(h) If a condenser is used, means must be provided for properly filtering the lubricating oil, if any, used in the engine from the condensed water before returning it to the boiler.

(22) If internal-combustion engines are used, it is desirable that means should be provided for starting the engine, putting it into gear, and starting the load without noise or shock.

(23) If friction clutches are used, the material forming the working surfaces of the clutch must be such that it will not require frequent renewing, and provision must be made that the clutch can be easily adjusted on the road.

(24) If liquid fuel is used, means must be provided for rapidly filling the tanks on the tractor.

NOTE.—In considering the merits of competing vehicles, special importance will be paid to the following points:

(a) Distance over which a gross load of 25 tons can be hauled at 3 miles an hour with the fuel and water that can be carried on the tractor without replenishment.

(b) Prime cost, having due regard to efficiency.

(c) Economy in working and maintenance.

(d) Ease of steering and manipulation.

(e) Simplicity of design, accessibility of parts, and the readiness with which repairs can be effected or worn parts replaced on the road.

(f) Absence of noise, vibration, smoke, or visible vapor.

(g) The means by which the working parts are prevented from being damaged by mud and dust.

(h) Capability of working with fuels varying in description and quality.

Trade School at Solingen.—Consul Langer reports from Solingen, October 26, 1901, in regard to a trade school recently organized in that city. He says:

It is obligatory for all tradesmen, whether apprentices, assistants, or factory laborers, to attend from four to six hours weekly until they reach the age of 17 years. The employer must pay into the city treasury the amount necessary for materials, viz., 3 marks (72 cents) annually, used by each person in his employ and under obligation to attend the school, but he can deduct such amount from the employé's compensation. The institution is supported by the city and State.

Furniture in Constantinople.—Deputy Consul-General Hanauer writes from Frankfort, October 25, 1901:

An article in the Moniteur Officiel du Commerce treats of the furniture trade in Constantinople, which is said to be constantly increasing. This trade, which formerly was supplied by French furniture exporters, now seems to be mainly in the hands of Italians, as their price and style suit the market better. Efforts have been made to introduce American furniture, which is admitted to be good and lower in price, but it is not made in accordance with the prevailing taste. Austria furnishes chairs and sideboards. Dining room and bed room sets are principally in demand.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

* See Advance Sheets No. 1,067 (June 20, 1901); Consular Reports No. 251.

TRADE NOTES AND RECEIPTS.

To Render Dried-Up Wooden Receptacles Water-tight.—When a wooden receptacle has dried up much it naturally cannot hold the water poured into it for the purpose of swelling it, and the pouring has to be repeated many times before the desired end is reached. A much quicker way is to stuff the receptacle full of straw or bad hay, laying a stone on top and then filling the vessel with water. Although the water runs off again the moistened straw remains behind and greatly assists the swelling up of the wood.—Die Werkstatt.

Testing the Quality of Potatoes.—Cut a potato in two and rub the two pieces together; if it is nice and mealy, the pieces will stick together, and at the edges and on the surface a light froth will appear. Water should not run out even upon pressure. If this is the case, they will boil watery and will have a bad taste.

The color of the meat should be white or have a tinge of yellow. It is asserted that entirely yellow potatoes do not boil well, but this is not always true, because there are some yellow varieties that leave nothing to be desired as regards quality.—Praktischer Rathgeber im Obst- und Gartenbau.

Cigar Ashes as a Remedy for Insect Bites.—Spirit of sal ammoniac, whose favorable action upon fresh insect bites is universally known, can frequently not be applied in out-of-the-way places for the simple reason that it is not at hand. A simple means to alleviate the pain and swelling due to such bites, when still fresh, is cigar ashes, which are more liable to be obtainable than spirit of sal ammoniac. Place a little ashes from a cigar, cigarette or pipe upon the part stung, add a drop of water—in case of need beer, wine or coffee may be used instead—and rub the resulting paste thoroughly into the skin. It is, of course, preferable to use fresh ashes of tobacco, because the recent heat offers sufficient guarantee for absolute freedom from impurities. The action of the tobacco ashes is due to the presence of potassium carbonate, which, like spirit of sal ammoniac, deadens the effect of the small quantities of acid (formic acid, etc.) which have been introduced into the small wound by the biting insect.—Pharmaceutische Centralhalle.

Preservation of Wine by Means of Carbonic Acid Saturated with Fumes of Spirit of Wine.—A process and a contrivance for the preservation of wine in the cask by carbonic acid saturated with spirit of wine has been patented in Germany by Eduard Frank, of Andernach. Upon the surface of the wine in the cask, as soon as wine is drawn from the latter, carbonic acid is conducted which has been saturated with spirit of wine in its passage through a receptacle. This receptacle is divided into an upper and a lower compartment. The upper compartment is filled with spirit of wine, the lower one with a porous body such as wadding, asbestos, etc. The lower compartment is divided by several vertical partitions in such a manner that the spirit of wine entering at one side traverses the receptacle in zigzag fashion. The porous substance, which lies on a sieve-bottom in the lower compartment, is continually saturated with spirit of wine in proportion to the amount used up, the latter reaching the lower compartment from the upper one through a pipe.—Technische Rundschau.

Soldering of Metallic Articles.—In hard-soldering metal articles of all kinds as practised heretofore, especially of iron or steel, it is endeavored, as is generally known, to prevent the solder from adhering to the surfaces not to be soldered by covering these surfaces with a mixture of graphite and water. Since the objects treated in this manner, however, have to be, as a rule, brushed off in a hot and hence softened condition, a shifting or bending frequently occurs at the soldering places, so that this process leaves much to be desired, even if the operation is conducted most carefully.

A new process is characterized by the parts to be united being covered, on the surfaces not to be soldered, before the soldering operation, with a new protective mass, which prevents an immediate contact of the solder with the said surfaces and has to be brushed off only after the soldered pieces have cooled perfectly, whereby the possibility of a change of position of these pieces seems precluded.

For the execution of this process the objects to be soldered, after the surfaces to be united have been provided with a waterglass solution as soldering agent and placed together as closely as possible or connected by wires or rivets, are coated in the places where no solder is desired with a protective mass, consisting essentially of coal (graphite, coke or charcoal), powdered talc or asbestos, ferric hydrate (with or without ferrous hydrate), and, if desired, a little aluminium oxide, together with a binding agent of the customary kind (glue solution, beer).

Following are some examples of the composition of these preparations:

1. Graphite 50 parts, powdered coke 5 parts, powdered charcoal 5 parts, powdered talc 10 parts, glue solution 2.5 parts, drop beer 2.5 parts, ferric hydrate 10 parts, aluminium oxide 5 parts.

2. Graphite, burnt, 4 parts, graphite, unburnt, 6 parts, powdered charcoal 3 parts, powdered asbestos 1 part, ferric hydrate 3 parts, ferrous hydrate 2 parts, glue solution 1 part.

The article thus prepared is entered, after the drying of the protective layer applied, in the metal bath serving as solder (molten brass, copper, etc.) and left to remain therein until the part to be soldered has become red hot, which generally requires about 50 to 60 seconds, according to the size of the object. In order to avoid, in introducing the article into the metal bath, the scattering of the molten metal it is well to previously warm the said article and to enter it in a warm state. After withdrawal from the metal bath the soldered articles are allowed to cool, and only then are cleaned with wire brushes, so as to cause the bright surfaces to reappear.

The process is especially useful for uniting iron or steel parts, such as machinery, arms and bicycle parts in a durable manner.—Neueste Erfindungen und Erfahrungen.

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